To the Editor of the Phil: Mag:
with the Translators Compts

PROFESSOR SCHEERER

UPON

POLYMERIC ISOMORPHISM.

FROM SILLIMAN'S JOURNAL,

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ART. XLIV.—*Upon a peculiar kind of Isomorphism that plays an important part in the Mineral Kingdom;* by Professor SCHEERER of Christiania.*

WHAT first led me to the discovery of the kind of isomorphism, the nature and frequent occurrence of which in the mineral kingdom it is purposed to enter upon in the present paper, was the examination of two minerals. One of these substances is a mineral already known, namely, *Cordierite;* the other, on the contrary, is a new mineral species, to which I have given the name *Aspasiolite.* I will at the outset detail my observations upon both these minerals, and then proceed to enter upon the inferences drawn therefrom.

1. *Cordierite.*—The cordierite that formed the subject of my investigations is met with in the vicinity of Krageröe, a sea town in the south of Norway, about eighteen English miles northeast of Tvedestrand, a town on the same coast and the well known locality of the beautiful blue cordierite, red garnet and crystallized titaniferous iron. The cordierite of Krageröe is not remarkable for anything like so deep a blue color as that of Tvedestrand; it is, generally speaking, of a pale amethystine tint or quite colorless, by which it assumes very much the appearance of common greasy quartz.

It is by no means an easy matter, owing to the considerable amount of alumina and magnesia that are contained in cordierite, to arrive at a correct analysis of the mineral. The separation of these earths by caustic potash or (when a considerable quantity of ammoniacal salts is contained in the solution) by caustic ammonia, is, as we are aware, only applicable when one of the earths in question is present in a comparatively small quantity. I therefore had recourse to another method, to which M. Henry Rose, in his work on analytical chemistry, gives the preference in cases where considerable quantities of these earths are to be separated. I put a considerable quantity of the solution of bicarbonate of soda required for the process in question into a large flask, and then added thereto, drop by drop, the acid solution containing the alumina, the magnesia, and the trifling portion of oxyd of iron of the cordierite. The bulk of this acid solution was at least fifty times less than that of the alkaline solution in the flask, and this latter was gently shaken as each drop of the acid solution was let fall into it. By this means the separation of these earths promised, I thought, to be more complete than when, on the contrary, the bicarbonate of soda is poured into the solution of the earths. I however found that the alumina thus precipitated was not free from magnesia. After separating it therefore by filtering and dissolving it in muriatic acid, it was treated again in a similar manner. But even now the alumina thrown down was not entirely free from magnesia, as was subsequently shown when it was treated with caustic potash, by which operation there was left undissolved a substance consisting chiefly of oxyd of iron, from which minute quantities of alumina and magnesia were precipitated. The principal amount of the magnesia that was held in solution by the bicarbonate of soda, was separated with the necessary precautions by boiling and other methods, the slight quantity of the oxyd of iron present which had been taken up with the magnesia in the large excess of the alkaline solution, having been previously thrown down by a few drops of sulph-hydrate of ammonia. This sulphuret of iron was not altogether free from traces of magnesia.

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* From Poggendorff's Annalen, vol. lxviii, p. 319; translated for this Journal by Mr. W. G. LETTSOM.

From two analyses of the Krageröe cordierite, in which the separation of the alumina and magnesia was performed as here described, the following results were obtained:

	I.	II.	Mean.
Silica, . . .	50·44	50·44	50·44
Alumina, . .	33·22	32·68	32·95
Magnesia, . .	12·43	13·08	12·76
Lime, . . .	1·08	1·17	1·12
Protoxyd of iron, .	0·79	1·12	0·96
Protoxyd of manganese,	trace.	trace.	trace.
Water, . . .	1·17	0·87	1·02
	99·13	99·36	99·25

The amount of silica could be determined in only one of these experiments, inasmuch as in one analysis the mineral was not fused with carbonate of soda but was attacked with fluoric acid.* The ratio of the oxygen of the silica to that of alumina and to that of the 1 : 1 atomic bases is consequently as follows:

$$\begin{array}{ccccc} \overset{\cdots}{\mathrm{Si}} & & \overset{\cdots}{\mathrm{Al}} & & \dot{\mathrm{R}} \\ 26{\cdot}20 & : & 15{\cdot}26 & : & 5{\cdot}48, \end{array}$$

assuming the small amount of iron in the mineral to be in the form of the protoxyd. This, however, can scarcely be the case with the cordierite here the subject of analysis, which was almost entirely colorless, and did not show the slightest tinge of green, whereas it is well known that, comparatively speaking, very minute quantities of the protoxyd of iron are sufficient for imparting to a silicate (when not in a pulverulent form) a decided green tinge, if not interfered with by the presence of other coloring substances. Assuming, therefore, and we are doubtless better borne out in doing so, that the iron is in the condition of a peroxyd, the ratio of the oxygen becomes

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* Plattner's apparatus was had recourse to for this fusion. The mass was not completely fused, but was rendered *thoroughly* attackable by hydrochloric acid. Frequent experience has convinced me of the great advantages which this apparatus offers to the mineralogical chemist whose time and trouble are materially saved thereby.

$$\begin{array}{ccccc} \dddot{\mathrm{Si}} & & \dddot{\mathbf{R}} & & \dot{\mathrm{R}} \\ 26{\cdot}20 & : & 15{\cdot}64 & : & 5{\cdot}26, \end{array}$$

agreeing very closely with the formula $\dot{\mathrm{R}}^3\,\dddot{\mathrm{Si}}^2+3\dddot{\mathbf{R}}\,\dddot{\mathrm{Si}}$, which would require a ratio of 26·20 : 15·72 : 5·24. The formula cited above is however that of the so-called hard fahlunite, whereas that of cordierite, according to Berzelius, has been hitherto held to be $3\dot{\mathrm{R}}^3\,\dddot{\mathrm{Si}}^2+8\dddot{\mathbf{Al}}\,\dddot{\mathrm{Si}}$.* The ratio of the oxygen agreeing with this last formula, is

$$\begin{array}{ccccc} \dddot{\mathrm{Si}} & & \dddot{\mathbf{Al}} & & \dot{\mathrm{R}} \\ 26{\cdot}20 & : & 14{\cdot}97 & : & 5{\cdot}62, \end{array}$$

and is therefore an approximation to the first that was obtained, in which the iron in the Krageröe cordierite was held to be in the state of a protoxyd. As it does not however appear to me that this assumption is fairly borne out, I here give the preference to the more simple formula $\dot{\mathrm{R}}^3\,\dddot{\mathrm{Si}}^2+3\dddot{\mathbf{R}}\,\dddot{\mathrm{Si}}$.

This leaves us to consider whether the constitution of cordierite from other localities may not be also expressed by this simpler formula. The ratio of the oxygen is, however,

1.	In the Cordierite from	Bodenmais,	according to	Stromeyer,	25·12 : 14·81 : 5·90
2.	"	Simiutak,	"	"	25·51 : 15·47 : 5·43
3.	"	Orijerfvi,	"	"	25·22 : 14·82 : 5·83
4.	"	"	"	von Bonsdorff,	25·95 : 15·36 : 5·18
5.	"	"	"	Thomson,	25·21 : 14·71 : 6·23
6.	"	Connecticut,	"	"	25·78 : 13·41 : 6·39

The mean of these six analyses gives

$$\begin{array}{ccccc} \dddot{\mathrm{Si}} & & \dddot{\mathbf{Al}} & & \dot{\mathrm{R}} \\ 25{\cdot}47 & : & 14{\cdot}76 & : & 5{\cdot}83, \end{array}$$

whereas, according to the formula $\dot{\mathrm{R}}^3\,\dddot{\mathrm{Si}}^2+3\dddot{\mathbf{Al}}\,\dddot{\mathrm{Si}}$, it should be 25·47 : 15·27 : 5·09. On the assumption, however, that, in these cordierites too, a small portion of the iron exists in the form of a protoxyd, the average ratio is convertible to

$$\begin{array}{ccccc} \dddot{\mathrm{Si}} & & \dddot{\mathbf{Al}} & & \dot{\mathrm{R}} \\ 25{\cdot}47 & : & 15{\cdot}27 & : & 5{\cdot}37, \end{array}$$

which agrees so closely with the formula $\dot{\mathrm{R}}^3\,\dddot{\mathrm{Si}}^3+3\dddot{\mathbf{R}}\,\dddot{\mathrm{Si}}$, that I cannot but look on this simpler expression as the true representative of all cordierites.

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* Or, more fully, $\dot{\mathrm{Fe}}^3\,\dddot{\mathrm{Si}}^2+2\dddot{\mathbf{Al}}\,\dddot{\mathrm{Si}}+2\,[\dot{\mathrm{Mg}}^3\,\dddot{\mathrm{Si}}^2+3\dddot{\mathbf{Al}}\,\dddot{\mathrm{Si}}]$.

Be this however as it may, it noways influences the deductions which, as will be seen below, we draw from the composition of the mineral in question, and the other formula may, with equal propriety, be looked upon as the correct one. It, nevertheless, struck me that the agreement of the formula of cordierite with that of the closely allied hard fahlunite, was a point of sufficient interest to justify these passing remarks.

2. *Aspasiolite.*—In most of its mineralogical characters, especially in color, lustre, translucency and hardness, this substance, which occurs at the same locality as the cordierite just described, agrees very closely with serpentine.* It is usually of a green color of various shades, mostly light, such as leek-green, asparagus-green, oil-green, &c. Here and there the mineral exhibits portions of a brown or reddish-brown color, which appears to me to be owing to an intermixture of oxyd of iron. The specific gravity of aspasiolite is somewhat higher than that of serpentine, namely, 2·764 (after drying in the water-bath and boiling in water). Perfectly pure portions of the mineral are but little harder than calc spar. In the various specimens that I possess of this substance it occurs associated with cordierite, quartz, feldspar and mica, (and now and then with titaniferous iron,) and this mineral admixture is met with in the primary gneiss of Krageröe, a formation remarkable for various magnesian minerals. As far as my present experience goes, it is but seldom met with crystallized. I am in possession of two fragments of distinct crystals of a considerable size, the diameter of one being about three-quarters of an inch; what the size of the other crystal was, it is not so easy to say exactly, owing to a piece being missed; it must, however, have been of a larger size than the former one. The form of the crystals will be mentioned in the sequel, as will also a peculiarity connected therewith.

Before the blowpipe, aspasiolite shows no distinctive characters. It is infusible, gives off water in the tube, and gives, when treated with salt of phosphorus and borax, the reaction of silica and iron. A preliminary qualitative examination shows it to consist chiefly of silica, alumina, magnesia, protoxyd of iron and water. Two analyses in which I separated the magnesia from the alumina as I have described above, and attached the mineral in a state of minute subdivision with boiling hydrochloric acid, gave me the following results:

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* I received both substances from Messrs. Dahl and Weibye of Krageröe, mineralogical students at this University, to whose kindness I am already indebted for several interesting minerals.

	I.	II.	Mean.
Silica,	50·29	50·51	50·40
Alumina,	32·40	32·35	32·38
Magnesia,	8·04	7·97	8·01
Lime,	trace.	trace.	trace.
Protoxyd of iron,	2·30	2·39	2·34
Protoxyd of manganese,	trace.	trace.	trace.
Water,	6·58	6·88	6·73
	99·61	100·10	99·86

The corresponding ratio of oxygen as deduced from the mean of those two analyses, is

$$\overset{\cdots}{\mathrm{Si}} \qquad \overset{\cdots}{\mathbf{Al}} \qquad \dot{\mathrm{R}} \qquad \dot{\mathbf{H}}$$
$$26{\cdot}18 : 15{\cdot}12 : 3{\cdot}63 : 5{\cdot}98.$$

On endeavoring to deduce from this a formula for aspasiolite by the usual methods, we do not arrive at anything like a satisfactory result. Even when small deviations are allowed from the proportions here obtained, we obtain expressions that are scarcely probable and noways in harmony with the formula of cordierite, though nevertheless, as will be immediately seen, both minerals, owing to the circumstances of their occurring together, stand in very close relation to each other.

On comparing the composition of aspasiolite with that of the cordierite of Krageröe, we see that the silica and alumina occur in nearly the same quantities in both substances, and that it is principally in the diminished amount of magnesia, consequent upon the considerable amount of water, that the constitution of the former mineral differs from that of the latter. This circumstance, remarkable enough in itself, becomes of more importance when we reflect that *the two minerals are precisely of the same crystalline form*, namely, rhombic prisms of 120° with combinations of $0P$, $\infty\bar{P}\infty$, and $\infty\breve{P}\infty$, that is to say, the ordinary crystalline form of cordierite. Even a closer connection between the two species is indicated by the circumstance, that not only *in one and the same specimen* the most perfect transition from one mineral to the other may be observed, but, first and foremost, from the crystals consisting *in part of aspasiolite and in part of cordierite*. The central portion of the crystals especially, is composed of the latter mineral, and passes into the other, as is shown not only by the different color of the two substances, but by their very different hardness, that is to say, that of quartz and calc spar. And that there is not the slightest reason to suppose that one of these substances is weathered or anything of that sort, is evident from the fact that the fresh and compact mass formed from the intimate admixture of two minerals in question, does not show any symptoms whatever of decomposition. None of the minerals that occur here, not even the mica or the feldspar, have lost anything of their lustre or of freshness in their fracture.

Under these circumstances the idea is forced upon us, that these two minerals, cordierite and aspasiolite, are *isomorphous*, and that this isomorphism is founded upon *the power which a certain amount of water has to replace a certain quantity of magnesia.* Calculation informs us that in this case, three equivalents of water would replace one equivalent of magnesia. Assuming this to be the case, and substituting magnesia* in accordance therewith for the amount of water contained in aspasiolite, we should obtain the following ratio of oxygen for this mineral,

$$\begin{array}{ccccc} \dddot{\mathrm{Si}} & & \dddot{\mathbf{Al}} & & \dot{\mathrm{R}} \\ 26{\cdot}18 & : & 15{\cdot}12 & : & 5{\cdot}63; \end{array}$$

whereas the corresponding ratio for the Krageröe cordierite was, as has been shown, 26·20 : 15·26 : 5·48. Both these ratios of oxygen become, therefore, by this substitution, all but precisely similar. Even assuming that in aspasiolite a minute portion of its iron (about half its amount) occurs as the peroxyd, would modify the above ratio but very immaterially; in that case we should have the numbers,

$$\begin{array}{ccccc} \dddot{\mathrm{Si}} & & \dddot{\mathbf{R}} & & \dot{\mathrm{R}} \\ 26{\cdot}18 & : & 15{\cdot}52 & : & 5{\cdot}37, \end{array}$$

thus approximating to the ratio of oxygen that we arrive at in reckoning the minute quantity of iron in the Krageröe cordierite as a peroxyd, by which, as before stated, the numbers we obtain are, 26·20 : 15·64 : 5·26.

Whatever view we are disposed to adopt therefore, in this respect, the result in every case is, *that the similar crystalline forms in aspasiolite and in cordierite, is to be explained upon the assumption that three equivalents of water can replace isomorphically one equivalent of magnesia.* So striking a result as this, in the present want of any analogous observations, could not, it is self-evident, although borne out by facts, be at once looked upon as thoroughly established; and I therefore set about investigating the truth of the matter from other points of view, to the utmost in my power.†

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* That is to say, in the *proportion* of $3\bar{\mathbf{H}}$ to $1\dot{\mathrm{Mg}}$, or in other words of $3\times112{\cdot}48=337{\cdot}44$ to $258{\cdot}35$; therefore for every *part by weight* of water, $\frac{258{\cdot}35}{337{\cdot}44}=0{\cdot}766$ *part by weight* of magnesia. For the 6·73 per cent. of water contained in aspasiolite, according to my analysis, we must therefore substitute $6{\cdot}73\times0{\cdot}766=5{\cdot}15$ per cent. of magnesia. In calculating the oxygen ratio it is not, as indeed may be directly inferred from what has been said, necessary first to work out such a substitution, and then to calculate the oxygen of the quantity of magnesia thus increased. All that is requisite is to divide the amount of the oxygen of the water by three, and to add the quotient thus obtained to the oxygen of the magnesia, by which means, in the example before us, the total amount of oxygen in $\dot{\mathrm{R}}=3{\cdot}63+\frac{1}{3}\times5{\cdot}98=5{\cdot}63$, as we find it given above.

† Something bearing the greatest analogy to Prof. Scheerer's views has, unless I am altogether mistaken, been published. I allude to what Prof. Fuchs says relative to a certain quantity of water replacing soda.—W. G. L.

It was to be expected that this peculiar species of isomorphism would not manifest itself by one insulated fact, but that, as far at least as the mineral kingdom is concerned, it must play a more or less important and general part, and that further proofs of the justice of my views would in consequence be drawn from the composition of other hydrous minerals. My attention was in the first case directed to an examination of one of the most common hydrous silicates of magnesia, serpentine.

3. *Serpentines.*—The analysis of serpentines from different localities has led to results which, as shown by the following table, differ very materially.

Serpentine from	$\dddot{\text{Si}}$	$\dot{\text{Mg}}$	$\dot{\text{Ca}}$	$\dot{\text{Fe}}$	$\dot{\text{Mn}}$	$\dot{\text{H}}$	Other constituents.
1. Snarum, according to Hartwall,	42·97	41·66	.	2·23	.	12·27	0·87 $\dddot{\mathbf{Al}}$
2. Sala, " Lychnell,	42·16	42·26	.	1·98	.	12·33	1·03 bitumen and $\ddot{\text{C}}$
3. Gullsjö, " Mosander,	42·34	44·20	.	.	.	12·38	0·89 $\ddot{\text{C}}$
4. Snarum, " my analysis,*	40·71	41·48	.	2·43	.	12·61	2·39 $\dddot{\mathbf{Al}}$
5. New York, " Beck,	41·00	41·26	2·39	1·85	.	13·50	
6. Fahlun, " Jordan,	40·32	41·76	.	3·33	.	13·54	
7. Hoboken, " Lynchnell,	41·67	41·25	.	1·48	.	13·80	1·37 bitumen and $\ddot{\text{C}}$
8. Fahlun, " Marchand,	40·52	42·05	.	3·01	.	13·85	0·21 $\dddot{\mathbf{Al}}$
9. Philippstadt, " Stromeyer,	41·66	37·16	.	4·05	2·02	14·72	
10. ? " John,	42·50	38·63	0·25	1·35	0·56	15·20	1·00 $\dddot{\mathbf{Al}}$
11. Massachusetts, " Shepard,	40·08	41·40	.	2·70	.	15·67	
12. Bare Hills, " Vanuxem,	42·69	40·00	.	1·16	.	16·11	0·87 $\ddot{\text{C}}$
13. New York, " Beck,	40·50	38·00	.	.	.	21·00	

What strikes us most in these various results, is the great difference with respect to the amount of water obtained, which ranges from 12·27 to 21. Upon calculating the oxygen ratios of all these serpentines, upon the assumption that 3 equivalents of water = 1 equivalent of magnesia, and deducting moreover the small amount of alumina that occurs in some of these serpentines as $\dddot{\mathbf{Al}}\,\dddot{\text{Si}}$, we obtain the following proportions:

	$\dddot{\text{Si}}$		$\dot{\text{R}}$
1.	21·91	:	20·27
2.	21·90	:	20·46
3.	21·99	:	20·78
4.	20·03	:	20·34
5.	21·30	:	21·09
6.	20·93	:	20·95
7.	21·65	:	20·39
8.	21·07	:	20·95
9.	21·64	:	20·12
10.	21·61	:	19·96
11.	20·82	:	21·28
12.	22·18	:	20·52
13.	21·04	:	20·93

or as a mean of these thirteen ratios, 21·39 : 20·62; or in other words, 100 : 96·4.

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* In this analysis the complete separation of the $\dddot{\mathbf{Al}}$ from the $\dot{\text{Mg}}$, was carefully attended to.

Whence we may infer, first, that all the serpentines in question, *notwithstanding their very different amount of water*, give very nearly one and the same oxygen ratio of $\dddot{Si}$ to $\dot{R}$, as soon as we conceive their water to be replaced by magnesia in the proportion of $3\dot{H} : 1\dot{Mg}$; and secondly, that this oxygen ratio, which from the mean of thirteen analyses is 100 : 96·4, may, disregarding the trifling discordance, be put down as = 1 : 1. This discordance of 3·6 per cent. is easily explained when we take into consideration the difficulty that there is in obtaining serpentine completely pure, and entirely free from all mechanical admixture, and how liable this mineral is, either by being dried at too high a temperature, or in consequence of becoming weathered, (whence it also takes up a small amount of carbonic acid,) to part with a small quantity of its water.

From the oxygen ratio, $\dddot{Si} : \dot{R} = 1 : 1$, we deduce for all serpentines, the simple formula of $[\dot{R}]^3\,\dddot{Si}$, the bracket including the $\dot{R}$ signifying that in this member a greater or lesser portion of the magnesia and bases isomorphic therewith, as for instance, $\dot{Fe}$, $\dot{Mn}$, and so forth, is replaced by a corresponding quantity of water in the ratio here stated. *This formula is however at the same time that of olivine,* $[\dot{R}^3\,\dddot{Si}$,] with this difference merely, namely, that in the latter *no magnesia* is replaced by water. *Hence, serpentine is to be looked upon as a hydrous olivine,* or in other words, as an olivine in which the water, as an isomorphic constituent, replaces a greater or less amount of the 1 : 1 atomic bases, whence we arrive at an explanation of the known fact, *that the crystallized serpentine from Snarum is of the same crystalline form as olivine. What aspasiolite is to cordierite, serpentine is to olivine.*

The remarkable serpentine crystals from Snarum, (some of which, with a corresponding width and thickness, attain the length of four inches and above,) have been held by some mineralogists to be pseudomorphous crystals of olivine. Whoever is acquainted personally with their locality, will assuredly refuse to adopt this view.*

The olivine form of these crystals, furnishes of course no direct *proof* of the conversion; it only engages us to endeavor to *seek for* such a proof. No such proof has hitherto been found, neither is it probable, as I have convinced myself by a careful inspection of the localities in question, that it will ever be met with. Not any where in the Snarum serpentine, is there any indication of that weathering or other decomposition of the rock, universally observed as accompanying such pseudomorphs as are here treated of. The crystals of serpentine, in themselves perfectly fresh and colored green by silicate of the protoxyd of iron, are either imbedded in magnesite not less fresh and showing brilliant planes of cleavage,* or else they occur in perfectly undecomposed titaniferous iron. Now and then upon breaking up the latter, portions of serpentine are met with *imbedded therein.* There are not met with here either clefts, cracks, or drusy cavities, indicative of any infiltration, formation of veins, or any thing of that kind; but serpentine, magnesite, titaniferous iron, mica, and some few other minerals met with here, occur closely and intimately mixed up together, forming a ribbon-shaped zone in the primitive gneiss, as has been demonstrated by Böbert in his article "Upon the Serpentine Formation in the primitive district of Modum."† There are met with, it is true, at this locality, crystals of serpentine more or less weathered, in which case, owing to the protoxyd of iron being raised to the peroxyd, they are of a dirty yellow or brownish color, and indeed most of the specimens preserved in collections present that appearance; the reason thereof is simple enough, and noways bears out the olivine hypothesis.

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* Tamnau, who visited the localities some years ago, has already expressed himself to that effect. See Pogg. Ann., vol. xlii, p. 462. Also, Böbert in *Gäa Norvegica*, part i, p. 135.

All these crystals are obtained from the upper portion of the rock where exposed to the weather, or else they are imbedded in the numerous detached fragments that have rolled down below, and which have been lying for years upon the moist ground exposed to the action of the air and humidity. These crystals, owing to the facility with which the magnesite (filled as it is with fissures) breaks to pieces in consequence of this action, are detached very easily from their matrix, whereas with crystals that are quite fresh, and obtained by blasting from the lower portions of the serpentine mass, it is very far from an easy matter to remove entirely the surrounding matrix in which they are so closely and intimately imbedded.

(*To be continued.*)

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* This was formerly supposed to be bitter-spar. See Pogg. Ann., vol. lxv, p. 292.

† See Gäa Norvegica, part i, p. 127.

Art. XLV.—*Matteucci's Lectures on Living Beings.*[*]

The name of Matteucci has long been connected with researches on the physical phenomena of living beings, and especially with investigations into the agency of electricity in these operations. His mind has gone forward in experimental investigation, unbiassed by prevailing speculations, pursuing truth with the teachable spirit required of the student of nature, and with an earnestness and fertility of resource, rarely if ever exceeded. His statements are, therefore, entitled to the highest consideration. He finds no support for a common speculative opinion that an animal is a machine moved by electricity; yet traces out analogies between the different forces that are of great interest.

His lectures were delivered before the University of Pisa. They were published in Italian and have since appeared in French and English; the latter edition is from a corrected copy, by the author, with important recent additions. The topics treated of, include all the phenomena of living beings that are properly physical, and Matteucci successfully endeavors to show that many deemed vital are in fact of this kind. He takes up the following subjects in order:—Molecular Attraction—Capillarity—Imbibition—Endosmose—Absorption—Digestion—Reproduction—Nutrition and Animal heat—Phosphorescence of Animals and Plants—Electrical effects—Action of Gravity,—Light and Caloric,—Nervous force—Muscular Contraction—Circulation—Voice—Hearing—Vision. The researches relating to muscular electricity and the relations between electricity and the nervous force have never been properly noticed in this Journal, and we continue this review of the work by citations of passages, which will exhibit, though imperfectly, the facts to the reader, referring to the work, which cannot be too highly recommended, for a fuller account.

'*Galvanoscopic Frog.*—A frog is prepared according to Galvani's usual method; that is, we cut it through the middle of its pelvis, separate carefully all the muscles of the thigh, and divide one of the lumbar plexuses as it passes out of the vertebral column. We then have a leg of the frog united to its long nervous filament or the crural nerve (see B, part of fig. 2, p. 394).

The frog thus prepared,—which I have called the *galvanoscopic frog*—is very useful in researches on the electric current. For this purpose we introduce the claws of a frog into a glass tube covered with an insulating varnish, take hold of the tube with the hand, and afterward bring any two parts of the body,

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[*] Lectures on Living Beings, by Carlo Matteucci, Professor in the University of Pisa, with numerous wood-cuts. Translated under the superintendence of Jonathan Pereira, M.D., F.R.S., Vice President of the Royal Medical and Chirurgical Society. American Edition, Lea & Blanchard, Philadelphia.

Art. VI.—*Upon a peculiar kind of Isomorphism that plays an important part in the Mineral Kingdom;* by Professor Scheerer of Christiania.*

(Continued from vol. v, p. 389)

The query might be started, how it is then, since aspasiolite and cordierite are so closely associated, that serpentine is not accompanied by olivine? This circumstance, which, it must be confessed, does appear paradoxical, I purpose to enter upon towards the close of this paper.

Upon the theory based on the above mentioned relations of cordierite and aspasiolite, being thus borne out by the precisely similar relations subsisting between olivine and serpentine, the probability was increased, that the part played by this species of isomorphism in the mineral kingdom was not one restrained within very narrow limits. And this opinion has taken a development more extended than I even imagined it might be susceptible of, as my investigations have been carried out. In the sequel I purpose touching upon the principal minerals concerned in this inquiry, and to develope their suitable formulæ, upon the supposition that their water may be treated as a basic constituent, capable of replacing in the ratio that has been stated, (viz. three atoms to one atom,) the magnesia, and consequently all the other bases isomorphous therewith, as for instance, protoxyd of iron, protoxyd of manganese, and so forth.

In order to express as simply as possible that in a member of a formula $\dot{R}$, a portion of the 1 : 1 atomic bases is replaced by more or less water, I have in these cases invariably made use of the sign $(\dot{R})$, as was already the case with regard to serpentine. The formula of aspasiolite would therefore, upon this principle, be $(\dot{R})^3 \dddot{Si}^2 + 3\dddot{\mathbf{R}} \dddot{Si}$. Prior to proceeding to the results of my calculations, let me however very briefly further elucidate the kind of isomorphism forming the subject of our investigations, in a chemical point of view. From the composition of aspasiolite and of serpentine, it follows that in the former, one equivalent $\dot{R}$ (one-third of the entire 1 : 1 atomic bases contained in cordierite) is not replaced by water *exactly.* It is likewise clear that, as in serpentine the amount of water ranges between 12, 27 and 21 per cent., it does not observe any definite atomic proportion relative to the portion of the 1 : 1 atomic bases not made good by water. This is to be explained as follows, in a very simple manner, strictly upon the principle of an isomorphic substitution.

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* From Poggendorff's Annalen, vol. lxviii, p. 319; translated for this Journal by Mr. W. G. Lettsom.

From the circumstance of three equivalents of water being able to replace isomorphically one equivalent of magnesia, it directly follows that combinations such as $\dot{\mathrm{Mg}}^3 \dddot{\mathrm{Si}}$, $\dot{\mathrm{Mg}}^2 \dddot{\mathrm{Si}} + 3\dot{\mathbf{H}}$, and $\dot{\mathrm{Mg}} \dddot{\mathrm{Si}} + 6\mathrm{H}$, must, of necessity, possess the same crystalline form. Such combinations therefore, under this common form, can occur mixed together in every possible proportion, and thereby explain the occurrence of *non-definite proportions* in the respective amounts of water and of magnesia, not only as met with in aspasiolite and in serpentine, but also, as may be deduced from the sequel, in a very considerable number of other minerals containing water.

I. SILICATES.

A. Silicates of magnesia and other bases isomorphous therewith, (minerals allied to serpentine.)

1. *Gymnite.* (Thomson.)

Oxygen ratio, $\dddot{\mathrm{Si}} : (\dot{\mathrm{R}}) = 20{\cdot}86 : 20{\cdot}56$. Formula deducible therefrom, $(\dot{\mathrm{R}})^3 \dddot{\mathrm{Si}}$.

$(\dot{\mathrm{R}})$ in this mineral = 36·00 $\dot{\mathrm{Mg}}$, 21·60 $\dot{\mathbf{H}}$, 0·80 $\dot{\mathrm{Ca}}$. In addition thereto, Thomson found in gymnite 1·16 ferriferous alumina. Deducting this as a $\frac{1}{3}$ silicate, the oxygen ratio given above becomes modified to 20·36 : 20·56, approximating therefore even yet closer to 1 : 1.

2. *Deweylite.* (Shepard.)

20·78 : 21·40. $(\dot{\mathrm{R}})^3 \dddot{\mathrm{Si}}$.

$(\dot{\mathrm{R}})$ = 40·0 $\dot{\mathrm{Mg}}$, 20·0 $\mathbf{H}$. The siliceous hydrate of alumina from Baltimore has a similar composition, according to Allan.

3. *Villarsite.* (Dufrènoy.)

20·47 : 21·37. $(\dot{\mathrm{R}})^3 \dddot{\mathrm{Si}}$.

$(\dot{\mathrm{R}})$ from two analyses = 45·33–47·37 $\dot{\mathrm{Mg}}$, 4·30–3·59 $\dot{\mathrm{Fe}}$, 2·86–2·42 $\dot{\mathrm{Mn}}$, 0·54–0·53 $\dot{\mathrm{Ca}}$, 0·46 $\dot{\mathrm{K}}$, 5·80 $\mathbf{H}$.

4. *Dermatine.* (Ficinus.)

19·74 : 18·79. $(\dot{\mathrm{R}})^3 \dddot{\mathrm{Si}}$.

$(\dot{\mathrm{R}})$ in two analyses = 23·70–19·33 $\dot{\mathrm{Mg}}$, 11·33–14·00 $\dot{\mathrm{Fe}}$, 2·25–1·17 $\dot{\mathrm{Mn}}$, 0·83–1·83 $\dot{\mathrm{Ca}}$, 0·50–1·33 $\dot{\mathrm{Na}}$, 25·20–22 $\dot{\mathbf{H}}$, and in addition thereto, 0·42–0·83 $\dddot{\mathbf{A}}\mathrm{l}$; deducting this latter as $\frac{1}{3}$ silicate, the oxygen ratio becomes altered to 19·44 : 18·79.

5. *Chrysotile.* (*Metaxite*, Delesse.)

21·90 : 20·60. $(\dot{\mathrm{R}})^3 \dddot{\mathrm{Si}}$.

$(\dot{\mathrm{R}}) = 41{\cdot}9\,\dot{\mathrm{Mg}},\ 3{\cdot}0\,\dot{\mathrm{Fe}},\ 13{\cdot}6\,\dot{\mathbf{H}}$, and in addition, $0{\cdot}4\,\dddot{\mathbf{Al}}$. The lustrous asbestus from Reichenstein has a similar composition, according to von Kobell, as has also the Baltimorite, according to Thomson. The oxygen ratio of the former is 22·4 : 20·04, and that of the latter, 20·57 : 19·45.

6. *Chlorophæite.* (Forchhammer.)

$$17{\cdot}07 : 17{\cdot}24. \qquad (\dot{\mathrm{R}})^3\,\dddot{\mathrm{Si}}.$$

$(\dot{\mathrm{R}}) = 3{\cdot}44\,\dot{\mathrm{Mg}},\ 21{\cdot}56\,\dot{\mathrm{Fe}},\ 42{\cdot}15\,\dot{\mathbf{H}}$.

All these minerals, whose amount of water varies from 5·80 to 42·15 per cent., have therefore the same formula as *serpentine*, and in a chemical point of view, are only distinct therefrom in consequence of the different but isomorphous composition of the member $(\dot{\mathrm{R}})$. Of these minerals, there is as yet but one that has been met with distinctly crystallized—this is villarsite. Its crystalline form belongs, like that of serpentine, to the rhombic system, but the prism of villarsite has angles of 120°, whereas those of serpentine are 130°. The macrodiagonals of both prisms are therefore as *tan* 65° : *tan* 60° = 2·144 : 1·732, or very nearly = 5 : 4. The form of villarsite therefore, may be supposed to be one derived from that of serpentine.

7. *Picrophyll.* (Svanberg.)

$$\left.\begin{array}{l}\text{Obtained, } 25{\cdot}87 : 16{\cdot}35\\ \text{Required, } 25{\cdot}00 : 16{\cdot}66\end{array}\right\}^{*} \qquad (\dot{\mathrm{R}})^2\,\dddot{\mathrm{Si}}.$$

$(\dot{\mathrm{R}}) = 30{\cdot}10\,\dot{\mathrm{Mg}},\ 6{\cdot}86\,\dot{\mathrm{Fe}},\ 0{\cdot}87\,\dot{\mathrm{Ca}}$, a trace of $\dot{\mathrm{Mn}}$, $9{\cdot}83\,\dot{\mathbf{H}}$, besides $1{\cdot}11\,\dddot{\mathbf{Al}}$. Deducting this latter as a $\frac{1}{3}$ silicate, the oxygen ratio becomes = 25·52 : 16·35, very nearly therefore as 3 : 2. The analysis gave 1·52 per cent. loss.

8. *Aphrodite.* (Berlin.)

$$\left.\begin{array}{l}26{\cdot}79 : 17{\cdot}11\\ 26{\cdot}79 : 17{\cdot}86\end{array}\right\} \qquad (\dot{\mathrm{R}})^2\,\dddot{\mathrm{Si}}.$$

$(\dot{\mathrm{R}})$ from two analyses = 33·72–34·07 $\dot{\mathrm{Mg}}$, 1·62–1·49 $\dot{\mathrm{Mn}}$, 0·59–0·55 $\dot{\mathrm{Fe}}$, 12·32–11·34 $\dot{\mathbf{H}}$, besides 0·20–0·13 $\dddot{\mathbf{Al}}$.

9. *Spadaite.* (v. Kobell.)

$$\left.\begin{array}{l}29{\cdot}09 : 15{\cdot}38\\ 29{\cdot}09 : 14{\cdot}55\end{array}\right\} \qquad (\dot{\mathrm{R}})^3\,\dddot{\mathrm{Si}}^2.$$

$(\dot{\mathrm{R}}) = 30{\cdot}67\,\dot{\mathrm{Mg}},\ 0{\cdot}66\,\dot{\mathrm{Fe}},\ 11{\cdot}34\,\dot{\mathbf{H}},\ 0{\cdot}66\,\dddot{\mathbf{Al}}$, 0·67 loss.

10. *Picrosmine.* (Magnus.)

$$\left.\begin{array}{l}28{\cdot}39 : 15{\cdot}16\\ 30{\cdot}00 : 15{\cdot}00\end{array}\right\} \qquad (\dot{\mathrm{R}})^3\,\dddot{\mathrm{Si}}^2.$$

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* For the facility of comparison, I have with all the following minerals given the oxygen ratio *as deduced from my formula, below* the ratio obtained from the analysis.

$(\dot{\text{R}}) = 33{\cdot}35\ \dot{\text{Mg}},\ 0{\cdot}42\ \dot{\text{Mn}},\ 7{\cdot}30\ \bar{\text{H}}$ (ammoniacal), $0{\cdot}79\ \dddot{\bar{\text{Al}}},\ 1{\cdot}40\ \dddot{\bar{\text{Fe}}}$, 1·85 loss.

11. *Monradite.* (A. Erdmann.)

$$\left.\begin{array}{l}29{\cdot}09 : 15{\cdot}39\\ 29{\cdot}09 : 14{\cdot}55\end{array}\right\}\quad (\dot{\text{R}})^3\ \dddot{\text{Si}}^2.$$

$(\dot{\text{R}}) = 31{\cdot}36\ \dot{\text{Mg}},\ 8{\cdot}56\ \dot{\text{Fe}},\ 4{\cdot}04\ \dot{\bar{\text{H}}}$, 0·4 excess.

12. *Talc.* (Berthier.)

(1.) From Little St. Bernhard.

$$\left.\begin{array}{l}30{\cdot}24 : 14{\cdot}49\\ 30{\cdot}12 : 15{\cdot}06\end{array}\right\}\quad (\dot{\text{R}})^3\ \dddot{\text{Si}}^2.$$

(2.) From St. Foix.

$$\left.\begin{array}{l}28{\cdot}88 : 13{\cdot}59\\ 28{\cdot}88 : 14{\cdot}44\end{array}\right\}\quad (\dot{\text{R}})^3\ \dddot{\text{Si}}^2.$$

In the former, $(\dot{\text{R}}) = 33{\cdot}2\ \dot{\text{Mg}},\ 4{\cdot}6\ \dot{\text{Fe}},\ 3{\cdot}5\ \bar{\text{H}}$; in the latter, $(\dot{\text{R}}) = 19{\cdot}7\ \dot{\text{Mg}},\ 11{\cdot}7\ \dot{\text{Fe}},\ 8{\cdot}1\ \dot{\text{Ca}},\ 2{\cdot}6\ \bar{\text{H}}$. The talc from St. Foix contains moreover $1{\cdot}7\ \dddot{\bar{\text{Al}}}$. Deducting this as a $\frac{2}{3}$ silicate, we obtain the oxygen ratio = 27·69 : 13·59, also very nearly = 2 : 1.

13. *Meerschaum.*

$$\left.\begin{array}{l}\text{(1.) From Cabanas, according to Berthier,}\\ \qquad 27{\cdot}95 : 15{\cdot}14.\\ \text{(2.) From Coulommiers, according to the same,}\\ \qquad 28{\cdot}05 : 15{\cdot}22.\\ \text{(3.) From Morocco, according to Damour,}\\ \qquad 28{\cdot}57 : 14{\cdot}28.\end{array}\right\}\quad (\dot{\text{R}})^3\ \dddot{\text{Si}}^2.$$

All the three oxygen ratios are more or less nearly = 2 : 1. Lychnell however has analyzed a meerschaum from the Levant, whose oxygen ratio is 31·62 : 14·11. Supposing this mineral not to have been too highly dried, and to have been in a state of purity, the formula $\dot{\text{Mg}}\ \dddot{\text{Si}} + \bar{\text{H}}$ must be adopted for it. *Spadaite*, *picrosmine*, *monradite*, *talc*, and perhaps also *meerschaum*, have, as is seen above, one and the same chemical formula. The amount of water in the member $(\dot{\text{R}})$ ranges between the limits 2·6 (talc) and 20 (meerschaum). Picrosmine, monradite and talc occur crystallized, and all three of them *in crystals belonging to the rhombic system.* In picrosmine the obtuse angles of the rhombic prism are very nearly 127°, in monradite 130°, and in talc 120°. The rhombic prism of monradite and of picrosmine agrees also very nearly with the prism of serpentine, whereas that of talc is the same as that of villarsite. This accordance may cause some surprise, inasmuch as the formula for serpentine and villarsite is $(\dot{\text{R}})^3\ \dddot{\text{Si}}$, whereas for the other three minerals the formula is $(\dot{\text{R}})^3\ \dddot{\text{Si}}^2$. From analogous instances however, we are aware that minerals which we may look upon as different grades of saturation of one and the same radical, (be it simple or compound,) affect, *in numerous instances*, the same, or at any rate a very similar crystalline form.*

14. *Retinalite.* (Thomson.)

$$\left.\begin{array}{lll} 21{\cdot}07\,\dddot{\mathrm{Si}} & :\ 13{\cdot}22\,(\dot{\mathrm{R}}) & :\ 4{\cdot}82\,\dot{\mathrm{Na}} \\ 20{\cdot}25 & :\ 13{\cdot}50 & :\ 4{\cdot}50 \end{array}\right\}\quad 2(\dot{\mathrm{R}})^3\,\dddot{\mathrm{Si}}+\dot{\mathrm{Na}}^2\,\dddot{\mathrm{Si}}.$$

$(\dot{\mathrm{R}}) = 18{\cdot}86\,\dot{\mathrm{Mg}}$, $20{\cdot}0\,\dot{\bar{\mathrm{H}}}$, $0{\cdot}62\,\dddot{\bar{\mathrm{Fe}}}$, $0{\cdot}30\,\dddot{\bar{\mathrm{Al}}}$, 0·84 loss.

15. *Some "Serpentine-like Minerals."* (Schweitzer.)†

(1.) From Monte Rosa, 22·65 : 20·50.
(2.) From Zermatt, 22·68 : 20·39.
(3.) From Col de Breona, 22·97 : 19·30.

Mean of the three analyses:

$$\left.\begin{array}{l} 22{\cdot}77 : 20{\cdot}06 \\ 22{\cdot}77 : 20{\cdot}24 \end{array}\right\}\quad 2(\dot{\mathrm{R}})^3\,\dddot{\mathrm{Si}}+(\dot{\mathrm{R}})^2\,\dddot{\mathrm{Si}}.$$

In the first member of this formula, $(\dot{\mathrm{R}})$ consists of magnesia, water and protoxyd of iron, whereas in the second it consists chiefly only of magnesia. The formula may therefore, and indeed with greater propriety, be thus expressed: $2(\dot{\mathrm{R}})^3\,\dddot{\mathrm{Si}}+\dot{\mathrm{Mg}}^2\,\dddot{\mathrm{Si}}$. In which case it is quite analogous to that of retinalite.

16. *Schillerspar.* (Köhler.)

$$\left.\begin{array}{l} 22{\cdot}59 : 17{\cdot}12 \\ 22{\cdot}83 : 17{\cdot}12 \end{array}\right\} 2(\dot{\mathrm{R}})^3\,\dddot{\mathrm{Si}}+(\dot{\mathrm{R}})^3\,\dddot{\mathrm{Si}}^2.$$

The 1 : 1 atomic bases are according to two analyses = 25·86 –26·16 $\dot{\mathrm{Mg}}$, 2·64 to 2·75 $\dot{\mathrm{Ca}}$, 10·92 $\dot{\mathrm{Fe}}$, 0·54 to 0·57 $\dot{\mathrm{Mn}}$, 12·43 $\dot{\bar{\mathrm{H}}}$. It appears more natural to assume that in the first member of this formula, $2(\dot{\mathrm{R}})^3\,\dddot{\mathrm{Si}}$, we should have *a portion* of the magnesia, and in addition thereto, *the whole* of the protoxyd of iron and the water as $\frac{1}{3}$ silicates; and in the second member of the formula, $(\dot{\mathrm{R}})^3\,\dddot{\mathrm{Si}}^2$, the remainder of the magnesia and the whole of the lime as $\frac{2}{3}$ silicates. This would give us the formula thus modified, $2(\dot{R})^3\,\dddot{Si}+(\dot{R})^3\,\dddot{Si}^2$. *Schillerspar may therefore be looked upon as consisting of two atoms of serpentine and one atom of augite.* And this is in accordance with the known fact, that the occurrence of schillerspar appears to be closely limited to formations in which serpentine is met with. In the above oxygen ratio, the presence of 2·37 $\dddot{\mathbf{Cr}}$, and of 1·28 to 1·73 $\dddot{\mathbf{Al}}$, is not taken into account. What part these substances probably play in the composition of the mineral in question, will be broached as a conjecture in the sequel.

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* One instance that occurs to me, is in Smaltine and Skutterudite. Although the formula of the former is $\mathrm{Co\,As}^2$, and that of the latter $\mathrm{Co\,As}^3$, yet their crystalline form is precisely alike. Another example is offered by the feldspars, whose atomic composition may be thus expressed.

$\dot{\mathrm{R}}$ $\dddot{\bar{\mathrm{Al}}}$ $\dddot{\mathrm{Si}}$
3 : 3 : 4 = Anorthite.
3 : 3 : 6 = Labrador, Ryacolite.
3 : 3 : 8 = Andesine.
3 : 3 : 9 = Oligoclase.
3 : 3 : 12 = Orthoclase, Albite.

In accordance herewith, the feldspars are different grades of saturation of a radical compounded of equal atoms of $\dot{\mathrm{R}}$ and $\dddot{\bar{\mathrm{Al}}}$.

† See Erdmann and Marchand's J. f. P. Ch., vol. xxxii, p. 499; and Pogg. Ann., vol. xlviii.

17. *Crocidolite.* (Stromeyer.)

$$\left.\begin{array}{l} 26{\cdot}61 : 11{\cdot}99 \\ 26{\cdot}61 : 11{\cdot}40 \end{array}\right\} \qquad 3(\dot{R})\,\dddot{Si}+2(\dot{R})^3\,\dddot{Si}^2.$$

$(\dot{R})$ from two analyses $= 34{\cdot}38\,\dot{Fe}$, $2{\cdot}48\,\dot{Mg}$, $0{\cdot}09\,\dot{Mn}$, $0{\cdot}03\,\dot{Ca}$, $7{\cdot}07\,\dot{Na}$, $4{\cdot}80\,\dot{\mathbf{H}}$. The constituents are present in such proportions as would also admit of the formula, $3(\dot{R})\,\dddot{Si}+2\,\dot{Fe}^3\,\dddot{Si}^2$. $(\dot{R})$ in this case comprehending the whole soda, water, and magnesia. Compare this formula with that of hornblende, $\dot{R}\,\dddot{Si}+\dot{R}^3\,\dddot{Si}^2$.

Retinalite, Schweitzer's "*serpentine-like minerals*" (to which forsooth, a general distinctive name should be given) and *schiller spar*, form therefore a peculiar group of minerals the formula of which consists of two other members, one of them being serpentine, and therefore containing water, while the other member consists of an anhydrous silicate, but which also contains, as in the former member, 1 : 1 atomic bases. Crocidolite approaches a hydrous hornblende.

B. Silicates of magnesia and of other bases isomorphous therewith in combination with aluminates and oxydates of iron.

Chlorite and the minerals allied thereto.

1. *Chlorite.*

$$\left.\begin{array}{lll} 16{\cdot}30\,\dddot{Si} & : 7{\cdot}85\,\dddot{Al} & : 17{\cdot}72\,(\dot{R}) \\ 15{\cdot}42 & : 7{\cdot}71 & : 18{\cdot}00 \end{array}\right\} \qquad 2(\dot{R})^3\,\dddot{Si}+(\dot{R})\,\dddot{\mathbf{Al}}.$$

The oxygen ratio here given, is calculated from the mean of five analyses, namely, two analyses by v. Kobell of the chlorite of Achmatoffsk, his analysis of the Schwarzenstein chlorite, Varrentrapp's analysis of the Achmatoffsk cholite, and v. Brüels of that from the Zillerthal.

2. *Chlorite-slate.* (Varrentrapp.)

$$\left.\begin{array}{l} 16{\cdot}39 : 5{\cdot}66 : 18{\cdot}84 \\ 16{\cdot}39 : 5{\cdot}46 : 18{\cdot}21 \end{array}\right\} \qquad 3(\dot{R})^3\,\dddot{Si}+(\dot{R})\,\dddot{\mathbf{Al}}.$$

This chlorite slate was from the Pfitschthal. The composition of chlorite bears therefore a very simple relation to that of chlorite slate.

3. *Ripidolite.*

1.) From Rauris, according to v. Kobell:
13·54 : 8·63 : 16·04.

(2.) From St. Gothardt, according to Varrentrapp:
13·18 : 8·64 : 15·81.

(3.) From the Zillerthal, according to v. Kobell:
14·19 : 9·70 : 16·76.

Mean of the three analyses:

$$\left.\begin{array}{l}13{\cdot}67 : 8{\cdot}99 : 16{\cdot}20\\ 13{\cdot}50 : 9{\cdot}00 : 16{\cdot}50\end{array}\right\} \qquad 3(\dot{R})^3\,\dddot{Si}+2(\dot{R})\,\dddot{\mathbf{Al}}.$$

4. *Pennine.* (Schweitzer.)

$$\left.\begin{array}{l}17{\cdot}38 : 4{\cdot}44 : 18{\cdot}80\\ 17{\cdot}38 : 4{\cdot}35 : 18{\cdot}83\end{array}\right\} \qquad 4(\dot{R})^3\,\dddot{Si}+(\dot{R})\,\dddot{\mathbf{Al}}.$$

The oxygen ratio is calculated from the mean of two experiments.

5. *Xanthophyllite.* (Meitzendorff.)

$$\left.\begin{array}{l}8{\cdot}47 : 20{\cdot}53 : 13{\cdot}20\\ 8{\cdot}80 : 19{\cdot}80 : 13{\cdot}20\end{array}\right\} \qquad 4(\dot{R})^3\,\dddot{Si}+3(\dot{R})^2\,\dddot{\mathbf{Al}}^3.$$

From the mean of four analyses.

6. *Leuchtenbergite.* (Komonen.)

$$\left.\begin{array}{l}17{\cdot}78 : 8{\cdot}38 : 16{\cdot}74\\ 17{\cdot}00 : 8{\cdot}50 : 15{\cdot}60\end{array}\right\} \qquad 4(\dot{R})^2\,\dddot{Si}+(\dot{R})^3\,\dddot{\mathbf{Al}}^2.$$

It is here assumed, in accordance indeed with Komonen, that this mineral contains no protoxyd of iron, but 3·33 per cent. of the peroxyd. Leuchtenbergite is of a pale yellow, almost, indeed, colorless, and can therefore scarcely be supposed to contain enough of the protoxyd to correspond with 3·33 $\dddot{\mathbf{Fe}}$. It is possible that the oxygen ratio may be 17·0 : 8·5 : 17, and this would agree more closely with the ratio obtained from analysis than what is given above. But in that case the formula would be, $2(\dot{R})^2\,\dddot{Si}+(\dot{R})^2\,\dddot{\mathbf{Al}}$, which does not, it is true, appear probable, inasmuch as the silica and the alumina are therein combined with equal quantities of base. It may be further supposed that the base in combination with the silica consists only of magnesia (with a certain quantity of lime), while that combined with the alumina is composed of magnesia and water. The mineral, it is to be observed, contains 35·36 $\dot{Mg}$, 1·75 $\dot{Ca}$, 8·68 $\dot{\mathbf{H}}$. The formula would then become modified as follows,

$$2\,\dot{Mg}^2\,\dddot{Si}+(\dot{R})^2\,\dddot{\mathbf{Al}}.$$

Cases analogous thereto have been already adduced, and there is another similar instance in the composition of the next mineral.

7. *Chlorite mineral,* from Taberg. (Svanberg.)*

$$\left.\begin{array}{l}18{\cdot}58 : 6{\cdot}09 : 16{\cdot}98\\ 18{\cdot}50 : 6{\cdot}16 : 16{\cdot}44\end{array}\right\}\quad 3(\dot{R})^2\,\dddot{Si}+(\dot{R})^2\,\dddot{\mathbf{Al}},$$

which formula may likewise be thus given, $3\dot{\mathrm{Mg}}^2\,\dddot{Si}+(\dot{R})^2\,\dddot{\mathbf{Al}}$.

The mineral contains 29·27 $\dot{\mathrm{Mg}}$, 2·07 $\dot{\mathrm{K}}$, 6·34 $\dot{\mathrm{Fe}}$, 1·64 $\dot{\mathrm{Mn}}$, 11·76 $\dot{\mathbf{H}}$, and these bases are present in such proportions as will admit of the entire magnesia and potash being combined with the silica, while the whole of the other *weaker* bases may be supposed to be in combination with the alumina. Hitherto, this mineral, notwithstanding its great external resemblance to chlorite, was reckoned among the micas, because the quantity of the 1 : 1 atomic bases which it contains (not counting the water therewith), is not sufficient for a member of the chlorite family; now however, by including the water among the basic constituents, the mineral in fact takes its place among the chlorite group.

8. *Kämmererite.* (Hartwall.)

$$\left.\begin{array}{l}19{\cdot}20 : 6{\cdot}90 : 16{\cdot}83\\ 19{\cdot}50 : 6{\cdot}50 : 16{\cdot}25\end{array}\right\}\quad 6(\dot{R})_2\,\dddot{Si}+(\dot{R})^3\,\dddot{\mathbf{Al}}.$$

Pyrosclerite (v. Kobell) appears to have the same formula, unless indeed the loss of 1·9 per cent. in the analysis should cause an alteration therein.

9. *Chloritoid.* (v. Bonsdorf.)

$$\left.\begin{array}{l}14{\cdot}28 : 16{\cdot}61 : 9{\cdot}95\\ 15{\cdot}00 : 15{\cdot}00 : 10{\cdot}00\end{array}\right\}\quad (\dot{R})^3\,\dddot{Si}^2+(\dot{R})\,\dddot{\mathbf{Al}}^2.$$

The analysis gave an excess of 1·64. $(\dot{R})=27{\cdot}05\ \dot{\mathrm{Fe}}$, 4·29 $\dot{\mathrm{Mg}}$, 0·30 $\dot{\mathrm{Mn}}$, 6·95 $\dot{\mathbf{H}}$. A. Erdmann has examined another chloritoid which contains no water, and which (as the mean of two analyses) gives the following oxygen ratio.

$$\left.\begin{array}{l}12{\cdot}95 : 21{\cdot}02 : 6{\cdot}82\\ 13{\cdot}00 : 19{\cdot}50 : 6{\cdot}50\end{array}\right\}\quad 2(\dot{R})\dddot{Si}+\dot{R}\,\dddot{\mathbf{Al}}^3,$$

this therefore, as has been remarked by Rammelsberg, is evidently another mineral.

10. *Soapstone.* (Svanberg.)

$$\left.\begin{array}{l}24{\cdot}32 : 3{\cdot}87 : 16{\cdot}39\\ 23{\cdot}40 : 3{\cdot}90 : 16{\cdot}90\end{array}\right\}\quad 6(\dot{R})^2\,\dddot{Si}+(\dot{R})\,\dddot{\mathbf{R}}.$$

$(\dot{R})=33{\cdot}3\ \dot{\mathrm{Mg}},\ 0{\cdot}7\ \dot{\mathrm{Ca}},\ 11{\cdot}0\ \dot{\mathbf{H}};\ \dddot{\mathbf{R}}=8{\cdot}0\ \dddot{\mathbf{Al}},\ 0{\cdot}4\ \dddot{\mathbf{Fe}}.$

11. *Cronstedite.*

The formula of this mineral, according to v. Kobell, is

$$\left.\begin{array}{l}\dot{\mathrm{Fe}}^3\\ \dot{\mathrm{Mn}}^3\\ \dot{\mathrm{Mg}}^3\end{array}\right\}\quad \dddot{Si}+\dddot{\mathbf{Fe}}\,\dot{\mathbf{H}}^3,$$

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* See Berzelius's Jahresbericht, Jahrg. 20, Part 2, p. 234.

which admits of being thus written $(\dot{R})^3\,\dddot{Si}+(\dot{R})\,\dddot{\mathbf{F}}e$. This formula differs from that of chlorite from the member $(\dot{R})\,\dddot{Si}$ being contained therein but singly, whereas in chlorite it is doubled, and that it contains peroxyd of iron instead of alumina. That cronstedtite finds a place among the minerals of the chlorite family by the new formula here proposed for it, is without doubt amply borne out by its external characters. Its crystalline form is a hexagonal prism, with a cleavage parallel to the terminal plane.

Chlorite, ripidolite, pennine and the other chlorite minerals treated of here, all receive, as is seen above, formulæ consisting of two members, and which, generally speaking, are very simple. One of these members consists of a silicate, the other of an aluminate or an oxydate of iron.

C. silicates of magnesia and alumina, and bases isomorphous therewith.

(*a.*) *Mica and micaceous minerals.*

1. *Mica from Iviken.* (Svanberg.)

$$\left.\begin{array}{l}36{\cdot}97 : 7{\cdot}74 : 2{\cdot}78\\ 36{\cdot}97 : 7{\cdot}40 : 2{\cdot}47\end{array}\right\}\qquad (\dot{R})\,\dddot{Si}^2+\dddot{\mathbf{R}}\,\dddot{Si}^3.$$

2. *Mica from Brattstad.* (The same.)

$$\left.\begin{array}{l}33{\cdot}08 : 12{\cdot}66 : 1{\cdot}93\\ 32{\cdot}00 : 12{\cdot}80 : 2{\cdot}13\end{array}\right\}\qquad (\dot{R})\,\dddot{Si}+2\dddot{\mathbf{R}}\,\dddot{Si}^2.$$

The analysis gave an excess of 0·89.

3. *Mica from Broddbo.* (The same.)

$$\left.\begin{array}{l}24{\cdot}92 : 16{\cdot}95 : 2{\cdot}39\\ 25{\cdot}00 : 16{\cdot}66 : 2{\cdot}77\end{array}\right\}\qquad (\dot{R})\,\dddot{Si}+2\dddot{\mathbf{R}}\,\dddot{Si}.$$

Very closely agreeing with the mica from Utön, Kimito, Fahlun and Ochotsk, according to the analyses of Henry Rose. If a small quantity of manganese which is given in Svanberg's analysis as oxyd is calculated as protoxyd, the formula agrees even closer, inasmuch as in that case the oxygen ratio is then = 24·92 : 16·61 : 2·73.

4. *Mica from Rosendal.* (The same.)

$$\left.\begin{array}{l}23{\cdot}07 : 7{\cdot}87 : 10{\cdot}45\\ 23{\cdot}61 : 7{\cdot}87 : 10{\cdot}49\end{array}\right\}\qquad 2(\dot{R})^2\,\dddot{Si}+\dddot{\mathbf{Al}}\,\dddot{Si}.$$

5. *Mica from Pargas.* (The same.)

$$\left.\begin{array}{l}22{\cdot}13 : 13{\cdot}31 : 6{\cdot}64\\ 23{\cdot}00 : 13{\cdot}20 : 6{\cdot}60\end{array}\right\}\qquad 3(\dot{R})^2\,\dddot{Si}+4\dddot{\mathbf{R}}\,\dddot{Si}.$$

The analysis gave 1·19 *loss*.

6. *Mica from Monroe.* (v. Kobell.)

$$\left.\begin{array}{l}20{\cdot}78 : 9{\cdot}85 : 11{\cdot}06\\ 21{\cdot}00 : 10{\cdot}50 : 10{\cdot}50\end{array}\right\}\qquad (\dot{R})^3\,\dddot{Si}+\dddot{\mathbf{R}}\,\dddot{Si}.$$

The same formula appears to apply to the mica from Miask and from Karosulik. According to v. Kobell's analysis, their respective oxygen ratio is; 21·88 : 9·18 : 10·15 and 21·30 : 9·26 : 11·14. The formula adduced, which is that of garnet, has been before applied to these micas, but from not including the water among the basic constituents, the analyses indicated a want of 1 : 1 atomic bases.

7. *Mica from Abborforss.* (Svanberg.)

$$\left.\begin{array}{l} 20{\cdot}49 : 15{\cdot}30 : 3{\cdot}67 \\ 20{\cdot}00 : 16{\cdot}00 : 4{\cdot}00 \end{array}\right\} \qquad (\dot{\mathrm{R}})^3\,\dddot{\mathrm{Si}}+\dddot{\mathbf{R}}\,\dddot{\mathrm{Si}}.$$

8. *Mica from Sala.* (The same.)

$$\left.\begin{array}{l} 22{\cdot}06 : 6{\cdot}01 : 13{\cdot}65 \\ 21{\cdot}00 : 7{\cdot}00 : 14{\cdot}00 \end{array}\right\} \qquad 2(\dot{\mathrm{R}})^3\,\dddot{\mathrm{Si}}+\dddot{\mathbf{R}}\,\dddot{\mathrm{Si}}.$$

9. *Pyrophyllite.* (Herrmann.)

$$\left.\begin{array}{l} 31{\cdot}06 : 13{\cdot}76 : 3{\cdot}54 \\ 31{\cdot}00 : 13{\cdot}78 : 3{\cdot}44 \end{array}\right\} \qquad 3(\dot{\mathrm{R}})\,\dddot{\mathrm{Si}}+2\,\dddot{\mathbf{A}}\mathrm{l}^2\,\dddot{\mathrm{Si}}^3.$$

The insignificant amount of iron in this mineral has been calculated as protoxyd (=1·16 per cent.), although it is cited as peroxyd. It may be remarked, that the color of the mineral is *green*, and the analysis indicated a slight excess.

10. *Pinite from Auvergne.* (C. Gmelin.)

$$\left.\begin{array}{l} 29{\cdot}07 : 13{\cdot}50 : 3{\cdot}00 \\ 29{\cdot}00 : 12{\cdot}88 : 3{\cdot}22 \end{array}\right\} \qquad 3\,(\dot{\mathrm{R}})\,\dddot{\mathrm{Si}}+2\dddot{\mathbf{R}}^2\,\dddot{\mathrm{Si}}^3.$$

This pinite has therefore the same formula as Herrmann's pyrophyllite, the preceding mineral. The difference between them consists but in this, 1st, that in pyrophyllite there is only alumina, whereas pinite contains peroxyd of iron as well, and 2d, that in the former $(\dot{\mathrm{R}})=4\dot{\mathrm{Mg}}$, $1{\cdot}6\,\dot{\mathrm{Fe}}$, $5{\cdot}62\,\dot{\mathbf{H}}$, in the latter $=3{\cdot}76\,\dot{\mathrm{Mg}}$ and $\dot{\mathrm{Mn}}$, $7{\cdot}89\,\dot{\mathrm{K}}$, $0{\cdot}39\,\dot{\mathrm{Na}}$, $1{\cdot}41\,\dot{\mathbf{H}}$. Both minerals appear to crystallize in the rhombic system. But it does not seem probable to me that they should affect *precisely* similar forms, inasmuch as the amount of potash contained in pinite is too considerable for that.

11. *Pinite from Penig.* (Scott.)

$$\left.\begin{array}{l} 21{\cdot}94 : 16{\cdot}04 ; 3{\cdot}02 \\ 25{\cdot}00 : 16{\cdot}67 : 2{\cdot}78 \end{array}\right\} \qquad (\dot{\mathrm{R}})\,\dddot{\mathrm{Si}}+2\,\dddot{\mathbf{A}}\mathrm{l}\,\dddot{\mathrm{Si}}.$$

This is the formula of the Broddbo mica. In the latter, $(\dot{\mathrm{R}})=8{\cdot}31\,\dot{\mathrm{K}}$, $1{\cdot}5\,\dot{\mathrm{Mn}}$, $3{\cdot}32\,\dot{\mathbf{H}}$; in pinite $=11{\cdot}35\,\dot{\mathrm{K}}$, $0{\cdot}75\,\dot{\mathrm{Ca}}$ and $3{\cdot}00\,\dot{\mathbf{H}}$. Assuming about a third of the iron in the mineral to exist in the state of the protoxyd, for which supposition, however, (excepting, perhaps, that the analysis indicates an excess of 0·76 per cent.) there is no particular ground, the oxygen ratio becomes,

$$\left.\begin{array}{l} 24{\cdot}94 : 15{\cdot}12 : 3{\cdot}63 \\ 24{\cdot}00 : 16{\cdot}00 : 4{\cdot}00 \end{array}\right\} \qquad (\dot{R})^3\, \dddot{Si}^2 + 4\dddot{\mathbf{R}}\, \dddot{Si},$$

which would give this pinite the same formula as the following mineral. The formula first stated represents it, however, evidently better.

12. *Gigantolite.* (Trolle Wachtmeister.)

$$\left.\begin{array}{l} 24{\cdot}04 : 16{\cdot}51 : 4{\cdot}21 \\ 24{\cdot}00 : 16{\cdot}00 : 4{\cdot}00 \end{array}\right\} \qquad (\dot{R})^3\, \dddot{Si}^2 + 4\, \dddot{\mathbf{R}}\, \dddot{Si}.$$

The analysis gave an *excess* of 1·56.

13. *Chlorophyllite.* (Jackson.)

$$\left.\begin{array}{l} 23{\cdot}48 : 12{\cdot}98 : 7{\cdot}75 \\ 24{\cdot}00 : 12{\cdot}00 : 8{\cdot}00 \end{array}\right\} \qquad (\dot{R})^2\, \dddot{Si} + \dddot{\mathbf{Al}}\, \dddot{Si}.$$

A small amount of potash (1·64 per cent.) was estimated only from the loss.

14. *Ottrelite.* (Damour.)

$$\left.\begin{array}{l} 22{\cdot}51 : 11{\cdot}50 : 7{\cdot}31 \\ 22{\cdot}50 : 11{\cdot}25 : 7{\cdot}50 \end{array}\right\} \qquad (\ddot{R})^2\, \dddot{Si} + \dddot{\mathbf{Al}}\, \dddot{Si}.$$

This and the foregoing mineral have the same formula. In point of fact, both minerals occur in the same crystalline form, that of a hexagonal prism. $(\dot{R})$ in Ottrelite $= 16{\cdot}72\, \dot{Fe}$, $8{\cdot}18\, \dot{Mn}$, $5{\cdot}66\, \dot{\mathbf{H}}$. In chlorophyllite $(\dot{R}) = 9{\cdot}6\, \dot{Mg}$, $8{\cdot}26\, \dot{Fe}$, $4{\cdot}1\, \dot{Mn}$, $1{\cdot}64\, \dot{K}$, $3{\cdot}6\, \dot{\mathbf{H}}$.

Although the amount of water in the above named *varieties of mica* and *micaceous minerals*, generally speaking, is but moderate, ranging, as it does, between about one and six per cent., yet it, in most instances, exercises a considerable influence upon the formula of these minerals. For the greater part of them contain such a limited portion of the 1 : 1 atomic bases, that their quantity of oxygen is materially increased by that of the water, even when the amount of the latter does not exceed two per cent. If we neglect this amount of water, or endeavor to treat it as hydrate-water, we arrive for the most part at improbable and complicated formulæ, neither indicative of symmetrical relations between themselves, nor when compared with the formulæ of other minerals; objections to which the formula here adduced, as far at least as the majority of them is concerned, are assuredly not liable. Many varieties of mica contain minute quantities, scarcely exceeding one per cent., of compounds of fluorine, especially fluorid of calcium and fluorid of magnesium, which were not here taken into account. It is probable they replace a portion of the corresponding 1 : 1 atomic bases.

(*b.*) *Non-micaceous minerals.*—(*a.*) *Crystalline.*

1. *Fahlunite.* (Trolle Wachtmeister.)

$$\left.\begin{array}{l}22{\cdot}89 : 14{\cdot}09 : 7{\cdot}30\\ 22{\cdot}90 : 14{\cdot}60 : 7{\cdot}30\end{array}\right\}\qquad (\dot{\mathrm{R}})^3\,\dddot{\mathrm{Si}}+2\,\dddot{\mathbf{R}}\,\dddot{\mathrm{Si}}.$$

From the mean of two analyses.

2. *Esmarkite.* (A. Erdmann.)

$$\left.\begin{array}{l}23{\cdot}88 : 14{\cdot}98 : 7{\cdot}40\\ 23{\cdot}00 : 15{\cdot}33 : 7{\cdot}66\end{array}\right\}\qquad (\dot{\mathrm{R}})^3\,\dddot{\mathrm{Si}}+2\,\dddot{\mathbf{A}}\mathrm{l}\,\dddot{\mathrm{Si}}.$$

The analysis gave a *loss* of 1·45. According to the above, fahlunite and esmarkite have the formula of epidote, as has likewise Meionite. In esmarkite $(\dot{\mathrm{R}})$=8·99 $\dot{\mathrm{M}}$g, 4·10 $\dot{\mathrm{N}}$a, 1·43 $\dot{\mathrm{F}}$e, 0·63 $\dot{\mathrm{M}}$n, 0·68 $\dot{\mathrm{K}}$, 3.20 $\dot{\mathbf{H}}$, in fahlunite 6·04 to 6·75 $\dot{\mathrm{M}}$g, 0·0 to 7·22 $\dot{\mathrm{F}}$e, 1·72 to 2·24 $\dot{\mathrm{M}}$n, 0·0 to 4·45 $\dot{\mathrm{N}}$a, 0·94 to 1·98 $\dot{\mathrm{K}}$, trace to 1·35 $\dot{\mathrm{C}}$a, 8·65 to 11·66 $\dot{\mathbf{H}}$.

3. *Pyrargillite.* (Nordenskjöld.)

$$\left.\begin{array}{l}22{\cdot}82 : 13{\cdot}51 : 7{\cdot}56\\ 22{\cdot}00 : 14{\cdot}66 : 7{\cdot}33\end{array}\right\}\qquad (\dot{\mathrm{R}})^3\,\dddot{\mathrm{Si}}+2\,\dddot{\mathbf{A}}\mathrm{l}\,\dddot{\mathrm{Si}},$$

formula of the two foregoing minerals, and likewise of the others cited above. $(\dot{\mathrm{R}})$ =5·30 $\dot{\mathrm{F}}$e, 2·90 $\dot{\mathrm{M}}$g and $\dot{\mathrm{M}}$n, 1·05 $\dot{\mathrm{K}}$, 1·85 $\dot{\mathrm{N}}$a, 15·47 $\dot{\mathbf{H}}$. Pyrargillite, as also fahlunite, appears to affect a rhombic crystalline form. That of esmarkite is not known.

4. *Praseolite.* (A. Erdmann.)

$$\left.\begin{array}{l}21{\cdot}27 : 13{\cdot}47 : 9{\cdot}16\\ 22{\cdot}00 : 13{\cdot}20 : 8{\cdot}80\end{array}\right\}\qquad 2\,(\dot{\mathrm{R}})^3\,\dddot{\mathrm{Si}}+3\,\dddot{\mathbf{A}}\mathrm{l}\,\dddot{\mathrm{Si}}.$$

5. *Zeuxite.* (Thomson.)

$$\left.\begin{array}{l}17{\cdot}37 : 14{\cdot}87 : 8{\cdot}16\\ 17{\cdot}50 : 15{\cdot}00 : 7{\cdot}50\end{array}\right\}\qquad 3\,(\dot{\mathrm{R}})^3\,\dddot{\mathrm{Si}}+2\,\dddot{\mathbf{A}}\mathrm{l}^3\,\dddot{\mathrm{Si}}^2.$$

6. *Roselane.* (Svanberg.)

$$\left.\begin{array}{l}23{\cdot}33 : 16{\cdot}37 : 4{\cdot}86\\ 23{\cdot}33 : 15{\cdot}55 : 5{\cdot}18\end{array}\right\}\qquad (\dot{\mathrm{R}})^2\,\dddot{\mathrm{Si}}+2\,\dddot{\mathbf{A}}\mathrm{l}\,\dddot{\mathrm{Si}}.$$

$(\dot{\mathrm{R}})$ =6·63 $\dot{\mathrm{K}}$, 3·59 $\dot{\mathrm{C}}$a, 2·45 $\dot{\mathrm{M}}$g, 6·53 $\dot{\mathbf{H}}$. The oxygen ratio of polyargite (Svanberg) resembles that of roselane very closely, viz., 22·93 : 16·69 : 4·80.

$(\dot{\mathrm{R}})$ =6·73 $\dot{\mathrm{K}}$, 5·55 $\dot{\mathrm{C}}$a, 1·43 $\dot{\mathrm{M}}$g a trace, $\dot{\mathrm{M}}$n, 5·29 $\dot{\mathbf{H}}$. Both minerals, moreover, have a similar cleavage, similar specific gravity and a similar color.

7. *Kirwanite.* (Thomson.)

$$\left.\begin{array}{l}21{\cdot}04 : 5{\cdot}32 : 12{\cdot}28\\ 21{\cdot}00 : 6{\cdot}00 : 12{\cdot}00\end{array}\right\}\qquad 6\,(\dot{\mathrm{R}})^2\,\dddot{\mathrm{Si}}+\dddot{\mathbf{A}}\mathrm{l}\,\dddot{\mathrm{Si}}.$$

8. *Stellite.* (The same.)

$$\left.\begin{matrix}24{\cdot}98 : 3{\cdot}70 : 12{\cdot}67\\ 25{\cdot}00 : 4{\cdot}17 : 12{\cdot}50\end{matrix}\right\}\quad 9(\dot{R})^2\,\dddot{Si}+\dddot{\mathbf{R}}^2\,\dddot{Si}^3.$$

It is here assumed that this mineral contains, not as Thomson asserts, 3·524 protoxyd of iron, but a corresponding quantity of peroxyd. The mineral, it must be remarked, is *snow-white*, and the alumina which amounts only to 5·301 would not, of itself, be sufficient. The formula of stellite would also answer for Thomson's vermiculite, whose oxygen ratio $=25{\cdot}50:3{\cdot}40:13{\cdot}26$, if indeed, as Thomson says, the whole of the iron is contained in the form of a protoxyd. Calculating a small portion thereof to exist in the state of peroxyd would afford an oxygen ratio still closer to that of stellite. The two minerals, however, in spite of similar formula, applicable perhaps to both, are essentially different from each other. For, whereas, in stellite $(\dot{R})=30{\cdot}96\,\dot{Ca}$, $5{\cdot}58\,\dot{Mg}$, $6{\cdot}108\,\dot{\mathbf{H}}$, in vermiculite $(\dot{R})=16{\cdot}12\,\dot{Fe}$, (or upon the aforesaid supposition somewhat less,) $16{\cdot}964\,\dot{Mg}$, $10{\cdot}276\,\dot{\mathbf{H}}$.

9. *Weissite.* (Trolle Wachtmeister.)

$$\left.\begin{matrix}31{\cdot}01 : 10{\cdot}17 : 5{\cdot}76\\ 31{\cdot}00 : 10{\cdot}33 : 5{\cdot}17\end{matrix}\right\}\quad (\dot{R})^3\,\dddot{Si}^2+2\,\dddot{\mathbf{A}}l\,\dddot{Si}.$$

Remark.—This is where *aspasiolite* belongs, whose formula, as has been already stated, is $(\dot{R})^3\,\dddot{Si}^2+3\,\dddot{\mathbf{R}}\,\dddot{Si}$.

10. *Rhodalite.* (Thomson.)

$$\left.\begin{matrix}29{\cdot}04 : 7{\cdot}38 : 7{\cdot}07\\ 29{\cdot}00 : 7{\cdot}25 : 7{\cdot}25\end{matrix}\right\}\quad 3(\dot{R})\,\dddot{Si}+\dddot{\mathbf{R}}\,\dddot{Si}.$$

$(\dot{R})$ consists *almost entirely of water*, inasmuch as it is $=1{\cdot}1\,\dot{Ca}$, $0{\cdot}6\,\dot{Mg}$ and $22{\cdot}0\,\dot{\mathbf{H}}$. According to Thomson, this mineral occurs in aggregated rectangular prisms.

11. *Neurolite.* (The same.)

$$\left.\begin{matrix}37{\cdot}92 : 8{\cdot}23 : 2{\cdot}77\\ 38{\cdot}00 : 7{\cdot}60 : 2{\cdot}53\end{matrix}\right\}\quad (\dot{R})\,\dddot{Si}^2+\dddot{\mathbf{A}}l\,\dddot{Si}^3,$$

formula of the Iviken mica. In that, $(\dot{R})=4{\cdot}661\,\dot{Mg}$, $3{\cdot}528\,\dot{K}$, $1{\cdot}292\,\dot{\mathbf{H}}$, and $1{\cdot}197\,\dot{Ca}$. In neurolite, $(\dot{R})=3{\cdot}25\,\dot{Ca}$, $1{\cdot}50\,\dot{Mg}$, $4{\cdot}30\,\dot{\mathbf{H}}$.

β. Amorphous.*

1. *Pitchstone.* (Du Menil.)

$$\left.\begin{matrix}37{\cdot}92 : 5{\cdot}65 : 3{\cdot}08\\ 38{\cdot}00 : 5{\cdot}43 : 3{\cdot}62\end{matrix}\right\}\quad 2(\dot{R})\,\dddot{Si}^2+\dddot{\mathbf{R}}\,\dddot{Si}^3.$$

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* Or at least apparently so. Some of these minerals consist perhaps of an aggregation of microscopic crystals.

The analysis showed however a *loss* of 2·24. The pitchstone was from the Triebischthale near Meissen. The same mineral was examined also by Erdmann; the oxygen ratio obtained by him was = 39·27 : 5·79 : 4·55, but this analysis gave an *excess* of 3·948. The stone appears indeed worthy of its name!* Knox moreover examined a pitchstone from Newry, whose oxygen ratio was 37·82 : 5·37 : 4·26, and the analysis of which indicated a very trifling loss only—not above 0·2 per cent. The above formula therefore cannot well be very far from the truth.

2. *Cimolite.* (Klaproth.)

$$\left.\begin{matrix} 32{\cdot}73 : 11{\cdot}12 : 3{\cdot}56 \\ 33{\cdot}00 : 11{\cdot}00 : 3{\cdot}66 \end{matrix}\right\} \qquad (\dot{\mathrm{R}})\,\dddot{\mathrm{Si}} + \dddot{\mathbf{A}}\mathrm{l}\,\dddot{\mathrm{Si}}^{2}.$$

This is the formula of soda-spodumene. In cimolite however, $(\dot{\mathrm{R}})$ consists only of *water*.

3. *Onkosine.* (v. Kobell.)

$$\left.\begin{matrix} 27{\cdot}28 : 14{\cdot}42 : 4{\cdot}26 \\ 28{\cdot}00 : 14{\cdot}00 : 4{\cdot}66 \end{matrix}\right\} \qquad (\dot{\mathrm{R}})\,\dddot{\mathrm{Si}} + \dddot{\mathbf{A}}\mathrm{l}\,\dddot{\mathrm{Si}},$$

the formula of labradorite and ryacolite. $(\dot{\mathrm{R}}) = 6{\cdot}38\,\dot{\mathrm{K}},\ 3{\cdot}82\,\dot{\mathrm{M}}\mathrm{g},\ 0{\cdot}80\,\dot{\mathrm{F}}\mathrm{e},\ 4{\cdot}60\,\dot{\mathbf{H}}$. The analysis showed a loss of 1 per cent.

4. *Pipestone.* (*Catlinite*, Jackson.)

$$\left.\begin{matrix} 29{\cdot}15 : 10{\cdot}22 : 5{\cdot}23 \\ 30{\cdot}00 : 10{\cdot}00 : 5{\cdot}00 \end{matrix}\right\} \qquad 3(\dot{\mathrm{R}})\,\dddot{\mathrm{Si}} + \dddot{\mathbf{R}}^{2}\,\dddot{\mathrm{Si}}^{3}.$$

$(\dot{\mathrm{R}}) = 12{\cdot}48\,\dot{\mathbf{H}},\ 2{\cdot}16\,\dot{\mathrm{C}}\mathrm{a},\ 0{\cdot}20\,\dot{\mathrm{M}}\mathrm{g}$, and $4{\cdot}58\,\dot{\mathbf{H}}$.

5. *Fettbol.* (Kersten.)

$$\left.\begin{matrix} 24{\cdot}11 : 8{\cdot}61 : 7{\cdot}26 \\ 24{\cdot}00 : 8{\cdot}00 : 8{\cdot}00 \end{matrix}\right\} \qquad (\dot{\mathrm{R}})^{3}\,\dddot{\mathrm{Si}}^{2} + \dddot{\mathbf{R}}\,\dddot{\mathrm{Si}}.$$

The analysis gave a *loss* of 2·59. $(\dot{\mathrm{R}}) = 24{\cdot}50\,\dot{\mathbf{H}}$. The formula is that of tachylite.

6. *Huronite.* (Thomson.)

$$\left.\begin{matrix} 23{\cdot}79 : 15{\cdot}84 : 5{\cdot}12 \\ 25{\cdot}00 : 15{\cdot}00 : 5{\cdot}00 \end{matrix}\right\} \qquad (\dot{\mathrm{R}})^{3}\,\dddot{\mathrm{Si}}^{2} + 3\dddot{\mathbf{A}}\mathrm{l}\,\dddot{\mathrm{Si}}.$$

$(\dot{\mathrm{R}}) = 8{\cdot}04\,\dot{\mathrm{C}}\mathrm{a},\ 4{\cdot}32\,\dot{\mathrm{F}}\mathrm{e},\ 1{\cdot}72\,\dot{\mathrm{M}}\mathrm{g},\ 4{\cdot}16\,\dot{\mathbf{H}}$. *Loss*, 2·04.

7. *Agalmatolite.* (Thomson.)

$$\left.\begin{matrix} 25{\cdot}88 : 14{\cdot}29 : 4{\cdot}47 \\ 25{\cdot}00 : 15{\cdot}00 : 5{\cdot}00 \end{matrix}\right\} \qquad (\dot{\mathrm{R}})^{3}\,\dddot{\mathrm{Si}}^{2} + 3\dddot{\mathbf{R}}\,\dddot{\mathrm{Si}}.$$

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* There is an untranslatable play upon the word "*pech*" here. I regret being unable to render it into English, as a joke in German, from its extreme rarity, always possesses a certain value.—*Translator.*

$(\dot{R}) = 6{\cdot}00\,\dot{Ca}$, $6{\cdot}8\,\dot{K}$, $5{\cdot}5\,\mathbf{H}$. Huronite and agalmatolite appear to have the same formula therefore, namely, that of aspasiolite. But in the latter, $(\dot{R}) = 6{\cdot}97$ to $8{\cdot}04\,\dot{Mg}$, $\dot{Ca}$, a trace, $2{\cdot}30$ to $2{\cdot}39\,\dot{Fe}$ (a part thereof perhaps as $\dddot{\mathbf{Fe}}$), $\dot{Mn}$ a trace, $6{\cdot}58$ to $6{\cdot}88\,\dot{\mathbf{H}}$.

8. ———, from Plombières. (Berthier.)

$$\left.\begin{matrix}22{\cdot}86 : 10{\cdot}28 : 8{\cdot}18\\ 23{\cdot}00 : 11{\cdot}50 : 7{\cdot}67\end{matrix}\right\}\qquad (\dot{R})^2\,\dddot{Si}+\dddot{\mathbf{Al}}\,\dddot{Si}.$$

1·0 *loss.* $(\dot{R}) = 25{\cdot}0\,\dot{\mathbf{H}}$, $2{\cdot}0\,\dot{Mg}$. The bole from Stolpen, which has been analyzed by Rammelsberg, appears to have the same formula. Its oxygen ratio is = 23·86 : 10·35 : 8·76, whereby it is to be noticed that a loss of 2·17 per cent. was obtained. $(\dot{R})$ in this bole $= 25{\cdot}86\,\dot{\mathbf{H}}$, $3{\cdot}90\,\dot{Ca}$.

9. *Nontronite*, from Villefranche. (Dufrénoy.)

$$\left.\begin{matrix}21{\cdot}13 : 11{\cdot}12 : 7{\cdot}73\\ 22{\cdot}00 : 11{\cdot}00 : 7{\cdot}33\end{matrix}\right\}\qquad (\dot{R})^2\,\dddot{Si}+\dddot{\mathbf{R}}\,\dddot{Si}.$$

Essentially this is the formula of the preceding mineral. $(\dot{R}) = 23{\cdot}0\,\dot{\mathbf{H}}$, $2{\cdot}37\,\dot{Mg}$. Chlorophyllite also (which see), and ottrelite (see likewise), have this formula.

10. *Kaolin.* (Forchhammer.)

Its formula, $\dddot{\mathbf{Al}}^3\,\dddot{Si}^4+6\dot{\mathbf{H}}$, may be also thus expressed:

$$(\dot{R})^2\,\dddot{Si}+3\dddot{\mathbf{Al}}\,\dddot{Si}.$$

11. *Nontronite*, from Andreasberg. (Biewend.)

$$\left.\begin{matrix}21{\cdot}35 : 11{\cdot}44 : 6{\cdot}39\\ 21{\cdot}00 : 12{\cdot}00 : 6{\cdot}00\end{matrix}\right\}\qquad 3(\dot{R})^2\,\dddot{Si}+4\dddot{\mathbf{Fe}}\,\dddot{Si},$$

formula of the Pargas mica, in which however, $(\dot{R}) = 10{\cdot}27\,\dot{Mg}$, $0{\cdot}75\,\dot{Mn}$, $0{\cdot}26\,\dot{Ca}$, $8{\cdot}45\,\dot{K}$, $3{\cdot}35\,\dot{\mathbf{H}}$, whereas $(\dot{R})$ in nontronite consists of water alone, (21·56 per cent.) The nontronite of Autun shows, according to Berthier's analysis, a similar oxygen ratio to that from Andreasberg, that is to say, 21·46 : 10·94 : 5·58. This would perhaps bear out the formula, $(\dot{R})^3\,\dddot{Si}^2+2\dddot{\mathbf{R}}\,\dddot{Si}$, which is at the same time that of scapolite and of amphodelite, and which requires an oxygen ratio of 21·5 : 10·75 : 5·38.

12. *Saponite.* (*Piotine*, Svanberg.)

$$\left.\begin{matrix}26{\cdot}45 : 5{\cdot}02 : 13{\cdot}76\\ 26{\cdot}00 : 5{\cdot}20 : 13{\cdot}86\end{matrix}\right\}\qquad 4(\dot{R})^2\,\dddot{Si}+\dddot{\mathbf{Al}}\,\dddot{Si}.$$

13. *Pinguite.* (Kersten.)

Its formula, $\dot{\mathrm{Fe}}\,\dddot{\mathrm{Si}}+\dddot{\mathbf{F}}\mathrm{e}^{2}\,\dddot{\mathrm{Si}}^{3}+15\mathbf{H}$, may be also thus written, $(\dot{\mathrm{R}})^{3}\,\dddot{\mathrm{Si}}+\dddot{\mathbf{F}}\mathrm{e}\,\dddot{\mathrm{Si}}$, which is the formula of garnet and likewise of the mica from Miask, Monroe and Karosulik.

14.

According to Löwigs and Wackenroder's analyses of the boles from Ellinghausen, Cap de Prudelles, and Säsebühl, these minerals have the formula, $\dddot{\mathbf{R}}^{2}\,\dddot{\mathrm{Si}}^{3}+9\dddot{\mathbf{H}}$, which may be also written, $(\dot{\mathrm{R}})^{3}\,\dddot{\mathrm{Si}}+2\dddot{\mathbf{R}}\,\dddot{\mathrm{Si}}$. This formula agrees essentially with that of pyrargillite (which see), and with that of the other minerals there cited. In bole however, $(\dot{\mathrm{R}})$ consists almost entirely of water, (24 per cent.,) with minute quantities of magnesia and lime.

15. *Iron lithomarge.* (Schüler.)

$$\left.\begin{array}{l}21{\cdot}64 : 14{\cdot}65 : 6{\cdot}55\\ 21{\cdot}00 : 14{\cdot}00 : 7{\cdot}00\end{array}\right\}\quad (\dot{\mathrm{R}})^{3}\,\dddot{\mathrm{Si}}+2\dddot{\mathbf{R}}\,\dddot{\mathrm{Si}},$$

formula of the preceding mineral, and others referred to above.

$\dot{\mathrm{R}}=14{\cdot}20\,\dot{\mathbf{H}},\ 3{\cdot}04\,\dot{\mathrm{Ca}},\ 2{\cdot}55\,\dot{\mathrm{Mg}},\ 1{\cdot}51\,\dot{\mathrm{Mn}},\ 0{\cdot}93\,\dot{\mathrm{K}}$.

16. *Halloylite,* from La Vouth and Thiviers. (Dufrénoy.)

(1.) From la Vouth, 21·12 : 15·72 : 7·11.
(2.) From Thiviers, 22·39 : 15·16 : 7·27.

Mean of the two analyses:

$$\left.\begin{array}{l}21{\cdot}76 : 15{\cdot}44 : 7{\cdot}19\\ 22{\cdot}00 : 14{\cdot}67 : 7{\cdot}33\end{array}\right\}\quad (\dot{\mathrm{R}})^{3}\,\dddot{\mathrm{Si}}+2\dddot{\mathbf{R}}\,\dddot{\mathrm{Si}},$$

formula of the preceding mineral. In the La Vouth halloylite, $(\dot{\mathrm{R}})$ consists entirely of water (24·83), but in that from Thiviers, of 22·30 $\dot{\mathbf{H}}$ and 1·70 $\dot{\mathrm{Mg}}$.

17. *Mountain Soap,* from Thuringia. (Bucholz.)

$$\left.\begin{array}{l}22{\cdot}86 : 14{\cdot}83 : 6{\cdot}21\\ 22{\cdot}00 : 14{\cdot}67 : 7{\cdot}33\end{array}\right\}\quad (\dot{\mathrm{R}})^{3}\,\dddot{\mathrm{Si}}+2\dddot{\mathbf{R}}\,\dddot{\mathrm{Si}},$$

formula of the preceding mineral. There are also altogether, independent of epidote and meionite, seven different minerals possessing the same formula, namely, fahlunite, esmarkite, pyrargillite, bole, iron lithomarge, halloylite from La Vouth and from Thiviers, and mountain soap from Thuringia. The various but isomorphous nature of $(\dot{\mathrm{R}})$ and $(\dddot{\mathbf{R}})$, and the different grades of crystalline development, appear to form the leading differences subsisting between these minerals. Epidote and meionite cannot however be held to be isomorphous with the other minerals of this group, inasmuch as in them $(\dot{\mathrm{R}})$ consists essentially of *lime.*

18. *Halloysite.*

(1.) From Liege, according to Berthier,
23·35 : 18·24 : 4·74.

(2.) From Guatequé, according to Boussingault,
23·90 : 18·78 : 4·94.

(3.) From Bayonne, according to Berthier,
24·26 : 17·28 : 4·74.

(4.) So-called tuesite, according to Thomson,
23·1 : 18·87 : 4·00.

Mean of these four analyses :

$$\left.\begin{array}{l}23\cdot63 : 18\cdot29 : 4\cdot48\\ 23\cdot00 : 18\cdot40 : 4\cdot60\end{array}\right\}\qquad (\dot{R})^3\,\dddot{Si}+4\dddot{\mathbf{Al}}\,\dddot{Si},$$

formula of diploite, (according to Rammelsberg.) In the three halloylites, $(\dot{R})$ consists entirely of water, in tuesite $(\dot{R})=13\cdot5\,\dot{\mathbf{H}}$, $0\cdot7\,\dot{Ca}$, $0\cdot5\,\dot{Mg}$.

19. *Gilbertite.* (Lehunt.)

$$\left.\begin{array}{l}23\cdot46 : 19\cdot47 : 3\cdot16\\ 23\cdot50 : 20\cdot14 : 3\cdot36\end{array}\right\}\qquad (\dot{R})^3\,\dddot{Si}+6\dddot{\mathbf{R}}\,\dddot{Si}.$$

1·98 *loss.* $(\dot{R})=4\cdot17\,\dot{Ca}$, $1\cdot90\,\dot{Mg}$, $4\cdot25\,\dot{\mathbf{H}}$.

20. *Cerolite.* (Maak.)

$$\left.\begin{array}{l}19\cdot72 : 5\cdot69 : 13\cdot16\\ 19\cdot50 : 6\cdot50 : 13\cdot00\end{array}\right\}\qquad 2(\dot{R})^3\,\dddot{Si}+\dddot{\mathbf{Al}}\,\dddot{Si},$$

formula of massive gehlenite, and of the Sala mica. $(\dot{R})=31\cdot00\,\dot{\mathbf{H}}$, $18\cdot02\,\dot{Mg}$.

21. *Chonikrite.* (v. Kobell.)

$$\left.\begin{array}{l}18\cdot54 : 7\cdot99 : 15\cdot24\\ 19\cdot00 : 7\cdot60 : 15\cdot20\end{array}\right\}\qquad 4(\dot{R})^3\,\dddot{Si}+\dddot{\mathbf{Al}}\,\dddot{Si}.$$

$(\dot{R})=22\cdot50\,\dot{Mg}$, $12\cdot60\,\dot{Ca}$, $1\cdot46\,\dot{Fe}$, $9\cdot00\,\dot{\mathbf{H}}$.

22. *Mountain Soap*, from Arnstedt. (Ficinus.)

$$\left.\begin{array}{l}21\cdot00 : 11\cdot62 : 14\cdot25^{*}\\ 12\cdot00 : 12\cdot00 : 12\cdot00\end{array}\right\}\qquad (\dot{R})^6\,\dddot{Si}+\dddot{\mathbf{R}}^2\,\dddot{Si}.$$

$(\dot{R})=3\cdot1\,\dot{Mn}$, $1\cdot1\,\dot{Ca}$, $43\cdot0\,\dot{\mathbf{H}}$.

The above mentioned *amorphous minerals*, which hitherto have all been looked upon as hydrates, receive by the introduction of the water as a basic constituent, very simple formulæ, in close agreement and harmony with those of other silicates.

(To be continued.)

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* Is 21·00 a misprint for 12·00? From the formula, this latter number is correct in the lower line.

Art. XVII.—*Upon a peculiar kind of Isomorphism that plays an important part in the Mineral Kingdom;* by Professor Scheerer of Christiania.

(Continued from p. 73.)

II. Borates.

1. *Datholite.*

None of the prior formulæ for datholite agree so well with its composition as that brought forward by Rammelsberg, namely,

$$2\dot{\mathrm{Ca}}^{3}\,\dddot{\mathrm{Si}}+\dot{\mathrm{B}}^{3}\,\dddot{\mathrm{Si}}^{2}+3\dot{\mathbf{H}}.$$

This formula, however, involves the improbability that the boracic acid is here viewed in the light of a base combined with the silica. This improbability may however be got over by writing the formula as follows: $3[\dot{\mathrm{Ca}}\,\dddot{\mathrm{Si}}+\mathrm{Ca}\,\dddot{\mathrm{R}}]+(\dot{\mathrm{R}})\,\dddot{\mathrm{Si}}$, wherein therefore, $(\dot{\mathrm{R}})=3\dot{\mathbf{H}}$.

2. *Botryolite.*

Rammelsberg's formula for this mineral is,

$$2\dot{\mathrm{Ca}}^{3}\,\dddot{\mathrm{Si}}+\dddot{\mathrm{B}}^{3}\,\dddot{\mathrm{Si}}+6\,\dot{\mathrm{H}},$$

which admits of conversion to $3[\dot{\mathrm{Ca}}\,\dddot{\mathrm{Si}}+\dot{\mathrm{Ca}}\,\dddot{\mathrm{B}}]+(\dot{\mathrm{R}})^{2}\,\dddot{\mathrm{Si}}$.

III. Phosphates.

A. *Phosphates of Iron.*

1. *Vivianite.*

According to Stromeyer's analysis, the vivianite of St. Agnes in Cornwall, consists of phosphoric acid 31·8125, protoxyd of iron 41·2266, water 27·4843 = 99·8934.

Hitherto all endeavors have been in vain to arrive at a formula that would represent in a satisfactory manner the results of this analysis by so celebrated an analyst as Stromeyer, and which was apparently conducted with such precision. Von Kobell's formula, which gives the closest approximation to the result, $\mathrm{Fe}^{3}\,\overset{\cdot\cdot\cdot\cdot\cdot}{\mathbf{P}}+8\dot{\mathbf{H}}$, requires a composition of phosphoric acid 28·69, protoxyd of iron 42·38, water 28·93 = 100·00.

This differs not immaterially from the result of the analysis, and moreover involves a ratio in the quantity of oxygen contained in the base, the acid and the water, which in a compound of so little complicated a nature can hardly be looked upon as probable. On calculating the water in Stromeyer's result as a base isomorphous with protoxyd of iron ($3\dot{\mathbf{H}}=1\dot{\mathrm{F}}\mathrm{e}$) which, after the number of proofs we have adduced thereof, we are fully borne out in doing, we obtain an oxygen ratio of 17·47 $\overset{\cdot\cdot\cdot\cdot\cdot}{\mathbf{P}}$: 17·53 $(\dot{\mathrm{Fe}})$, corresponding with almost mathematical accuracy to the simple formula $(\dot{\mathrm{Fe}})^5\,\overset{\cdot\cdot\cdot\cdot\cdot}{\mathbf{P}}$, and in which formula *base and acid contain equal amounts of oxygen.*

2. *Earthy Vivianite*, from Hillentrup.

This consists, according to an analysis of Brandes, of phosphoric acid 30·320, protoxyd of iron 43·775, water 25·000, alumina 0·700, silica 0·025=99·820.

The oxygen ratio deduced herefrom is as follows: 18·60 : 17·38.

Deducting the alumina as a phosphate, the ratio becomes even more nearly 1 : 1, whence we also obtain for this mineral too the formula $(\dot{\mathrm{Fe}})^5\,\overset{\cdot\cdot\cdot\cdot\cdot}{\mathbf{P}}$.

3. *Vivianite*, from Bodenmais.

Vogel's analysis gave, phosphoric acid 26·4, protoxyd of iron 41·0, water 31·0=98·4.

If we may rely on the accuracy of this result, it will justify the following formula, $(\dot{\mathrm{Fe}})^5\,\overset{\cdot\cdot\cdot\cdot\cdot}{\mathbf{P}}+5\dot{\mathbf{H}}$.

The oxygen ratio as it may be calculated from the result of

the analysis, is, 14·79 $\overset{\cdot\cdot\cdot\cdot\cdot}{\mathbf{P}}$: 14·00 $(\dot{\mathrm{Fe}})$: 13·58 $\dot{\mathbf{H}}$
should be 14·00 : 14·00 : 14·00.

A portion of the water in this mineral is *basic*, another portion exists as a hydrate. The formula thus resulting for the Bodenmais vivianite, is precisely similar to that which we obtain upon converting, on the principle here involved, the formula of the artificially prepared hydrous phosphate of magnesia, which is $\dot{\mathrm{Mg}}^2\,\overset{\cdot\cdot\cdot\cdot\cdot}{\mathbf{P}}+14\dot{\mathbf{H}}$, whereby we obtain $(\dot{\mathrm{Mg}})^5\,\overset{\cdot\cdot\cdot\cdot\cdot}{\mathbf{P}}+5\dot{\mathbf{H}}$.

The corresponding artificial salts of the protoxyd of iron and of the protoxyd of manganese, have not as yet been analyzed, but without a doubt the same formula is also applicable to them. It would however be well to submit the Bodenmais vivianite to a further examination in order to ascertain with certainty whether in point of fact its composition is different from that from Cornwall, which as the two minerals agree in their crystalline form is certainly not probable.

4. *Mullicite.*

Thompson obtained for the composition of this mineral, phosphoric acid 26·06, protoxyd of iron 46·31, water 27·14=99·51.

The corresponding oxygen ratio is, 14·60 $\overset{\cdot\cdot\cdot\cdot\cdot}{\mathbf{P}}$: 14·00 $(\dot{\mathrm{Fe}})$: 13·75 $\dot{\mathbf{H}}$, which gives as the formula of mullicite $(\dot{\mathrm{Fe}})^5\,\overset{\cdot\cdot\cdot\cdot\cdot}{\mathbf{P}}+5\dot{\mathbf{H}}$, agreeing with Vogel's analysis of the Bodenmais vivianite. The chemical difference between both minerals would consist therefore merely herein, that in the former a smaller quantity of the protoxyd of iron is replaced by water than in the latter.

5. *Vivianite from the Mauritius.*

According to the analysis of Laugier it consists of phosphoric acid 21, protoxyd of iron 45, water 34=100.

From these numbers we can, it is true, surmise no great accuracy, nevertheless they afford an oxygen ratio of 11·77 $\overset{\cdot\cdot\cdot\cdot\cdot}{\mathbf{P}}$: 10·25 Fe : 30·11 $\dot{\mathbf{H}}$, corresponding approximately to the formula $\dot{\text{Fe}}^5\,\overset{\cdot\cdot\cdot\cdot\cdot}{\mathbf{P}}+15\dot{\mathbf{H}}$, according to which the oxygen ratio should be 10 : 10 : 30. In this mineral, therefore, the *whole* of the water appears to exist as a *hydrate.* The formula however admits of being thus written, $(\dot{\text{Fe}})^{10}\,\overset{\cdot\cdot\cdot\cdot\cdot}{\mathbf{P}}$, in which case the whole of the water figures as basic.

B. *Phosphates of Copper.*

As oxyd of copper is not isomorphous with magnesia, protoxyd of iron, &c., it of course cannot be assumed that three atoms of water replace one atom of oxyd of copper. From grounds which I will afterwards explain, there is more than a probability that two atoms of water can replace one of oxyd of copper. That less water should be required to replace one atom of oxyd of copper than one atom of magnesia, is sufficiently substantiated by the different basic qualities of these compounds. In calculating the oxygen ratio of the following phosphates and arseniates of copper, it is assumed, as yet hypothetically, that $2\dot{\mathbf{H}}=1\dot{\text{Cu}}$.

1. *Libethenite.*

The crystallized Libethenite consists, according to Berthier's analysis, of phosphoric acid 28·7, oxyd of copper 63·9, water 7·4=100·0. This gives, upon the above supposition, an oxygen ratio of 16·08$\overset{\cdot\cdot\cdot\cdot\cdot}{\mathbf{P}}$: 16·18$(\dot{\text{Cu}})$, corresponding exactly to the formula $(\dot{\text{Cu}})^5\,\overset{\cdot\cdot\cdot\cdot\cdot}{\mathbf{P}}$, which is the formula of the Cornwall vivianite and of the eathy vivianite from Hillentrup.

2. *Phosphorochalcite.*

Rammelsberg calculated from Lynn's analysis of the phosphorochalcite from Rheinbreitenbach, the formula $\dot{\text{Cu}}^5\,\overset{\cdot\cdot\cdot\cdot\cdot}{\mathbf{P}}+5\dot{\mathbf{H}}$, coinciding completely with the formula here adduced for the phosphates. According to the analysis perhaps a portion (though for a certainty but a very small one) of the oxyd of copper may be replaced by water, and the formula in consequence becomes $(\dot{\mathrm{Cu}})^5 \overset{\cdot\cdot\cdot\cdot\cdot}{\mathbf{P}} + 5\dot{\mathbf{H}}$, agreeing with the Bodenmais vivianite and mullicite.

3. *Phosphate of Copper*, from Ehl, near Rheinbreitenbach.

This consists, according to Bergmann, of phosphoric acid 24·93, oxyd of copper 65·99, water 9·06 = 99·98, corresponding to the oxygen ratio $13{\cdot}99\,\overset{\cdot\cdot\cdot\cdot\cdot}{\mathbf{P}} : 13{\cdot}31\,\dot{\mathrm{Cu}} : 8{\cdot}05\,\dot{\mathbf{H}}$; whence we deduce the formula, $3\dot{\mathrm{Cu}}^5 \overset{\cdot\cdot\cdot\cdot\cdot}{\mathbf{P}} + 10\dot{\mathbf{H}}$, requiring an oxygen ratio of 13 : 13 : 8·66.

4. *Phosphate of Copper*, from Hirschberg.

According to Kühn, its constituents are, phosphoric acid 20·87, oxyd of copper 71·73, water 7·40 = 100·00; whence we obtain the oxygen ratio,

$$\left.\begin{array}{l} 11{\cdot}69\,\overset{\cdot\cdot\cdot\cdot\cdot}{\mathbf{P}} : 17{\cdot}66\,(\dot{\mathbf{R}}) \\ 11{\cdot}69 \quad : 17{\cdot}54 \end{array}\right\} \qquad (\dot{\mathrm{Cu}})^{15} \overset{\cdot\cdot\cdot\cdot\cdot}{\mathbf{P}}{}^{2}.$$

IV. ARSENIATES.

As the relative quantities of the peroxyd and the protoxyd of iron have not yet been ascertained with accuracy in scorodite and in pharmacolite, no calculations can be here entered upon with respect to the formula these minerals would receive, by considering their water as a basic constituent.

A. *Arseniates of Earths.*

Picropharmacolite.

The analysis of Stromeyer gives arsenic acid 46·971, lime 24·646, magnesia 3·223, oxyd of cobalt 0·998, water 23·977 = 99·815, corresponding to—

$$\left.\begin{array}{l} 16{\cdot}30\,\overset{\cdot\cdot\cdot\cdot\cdot}{\mathbf{A}}\mathrm{s} : 15{\cdot}47\,(\dot{\mathbf{R}}) \\ 16{\cdot}00 \qquad : 16{\cdot}00 \end{array}\right\} \qquad (\dot{\mathrm{R}})^5\, \overset{\cdot\cdot\cdot\cdot\cdot}{\mathbf{A}}\mathrm{s},$$

the formula of vivianite, libethenite, and earthy blue iron. Since *pharmacolite* contains no earth but *lime*, it is not to be assumed that any replacement by water is brought into play in that mineral.

B. *Arseniates of Cobalt.*

Cobalt Bloom.

According to Berzelius, its formula is $\dot{\mathrm{C}}\mathrm{o}^3 \overset{\cdot\cdot\cdot\cdot\cdot}{\mathbf{A}}\mathrm{s} + 6\dot{\mathbf{H}}$, which, as protoxyd of iron and protoxyd of cobalt are isomorphous, and as we may make $3\dot{\mathbf{H}} = 1\dot{\mathrm{C}}\mathrm{o}$, may be expressed likewise thus, $(\dot{\mathrm{C}}\mathrm{o})^5 \overset{\cdot\cdot\cdot\cdot\cdot}{\mathbf{A}}\mathrm{s}$, by which it is rendered analogous to the Cornish vivianite; and the agreement that has been proved by Gustavus Rose to exist between the forms of the crystals of these two minerals, would be thus farther borne out. According to Kersten's analysis of the cobalt bloom from Schneeberg, the formula for this mineral is however, $\dot{\mathrm{Co}}^3\,\overset{\cdot\cdot\cdot\cdot\cdot}{\mathbf{As}}+8\dot{\mathbf{H}}$.

C. *Arseniates of Copper.*

1. *Olivenite.*

Richardson found the crystallized olivenite to consist of—

Arsenic acid, . .	39·9	39·80
Oxyd of copper, . .	56·2	56·65
Water, . . .	3·9	3·55
	100·0	100·00

The mean oxygen ratio from these two analyses is—

$$\left.\begin{array}{lcl} 13{\cdot}83\,\overset{\cdot\cdot\cdot\cdot\cdot}{\mathbf{As}} & : & 13{\cdot}04\,(\dot{\mathrm{Cu}}) \\ 13{\cdot}00 & : & 13{\cdot}00 \end{array}\right\} \qquad (\dot{\mathrm{Cu}})^5\,\overset{\cdot\cdot\cdot\cdot\cdot}{\mathbf{As}}.$$

This too is the formula of vivianite and of the other minerals cited. It is assumed that $2\dot{\mathbf{H}}=1\dot{\mathrm{Cu}}$.

2. *Euchroite.*

The euchroite from Libethen consists, according to Turner, of arsenic acid 32·02, oxyd of copper 47·85, water 8·80 = 99·67. From this the following oxygen ratio may be deduced, $11{\cdot}47\,\overset{\cdot\cdot\cdot\cdot\cdot}{\mathbf{As}} : 12{\cdot}00\,(\dot{\mathrm{Cu}}) : 12{\cdot}01\,\dot{\mathbf{H}}$, approaching very closely the ratio calculated for phosphorochalcite, and whence may be deduced the formula, $(\dot{\mathrm{Cu}})^5\,\overset{\cdot\cdot\cdot\cdot\cdot}{\mathbf{As}}+5\dot{\mathbf{H}}$. In euchroite however, a larger portion of the water (about one-fourth of the whole amount) plays the part of a base, than is the case in phosphorochalcite.

3. *Copper-foam.*

According to v. Kobell's analysis, the formula of the diverging foliated copper-foam from Falkenstein, is $\dot{\mathrm{Cu}}^5\,\overset{\cdot\cdot\cdot\cdot\cdot}{\mathbf{As}}+10\dot{\mathbf{H}}$, not taking into account the quantity of carbonate of lime therein contained, the amount of which approaches 1 atom.

4. *Erinite.*

From Turner's approximative analysis of this mineral, its constituents are arsenic acid 33·78, oxyd of copper 59·44, water 5·01, alumina 1·77 = 100·00. Neglecting the alumina, this gives the following oxygen ratio, $11{\cdot}73\,\overset{\cdot\cdot\cdot\cdot\cdot}{\mathbf{As}} : 11{\cdot}99\,\dot{\mathrm{Cu}} : 4{\cdot}45\,\dot{\mathbf{H}}$, whence may be deduced the formula, $2\dot{\mathrm{Cu}}^5\,\overset{\cdot\cdot\cdot\cdot\cdot}{\mathbf{As}}+5\dot{\mathbf{H}}$, or perhaps rather, $3\dot{\mathrm{Cu}}^5\,\overset{\cdot\cdot\cdot\cdot\cdot}{\mathbf{As}}+5\dot{\mathbf{H}}$. The former requires an oxygen ratio of 11 : 11 : 5·5,—the latter of 12 : 12 : 4.

5. *Copper Mica.*

The composition of the Cornish copper mica, according to Chenevix, is arsenic acid 21, oxyd of copper 58, water 21 = 100, corresponding to the oxygen ratio, $7{\cdot}29\,\dddot{\mathbf{A}}\mathrm{s} : 11{\cdot}70\,\dot{\mathrm{C}}\mathrm{u} : 18{\cdot}67\,\dot{\mathbf{H}}$, which may be likewise thus expressed, $7{\cdot}29\,\dddot{\mathbf{A}}\mathrm{s} : 15{\cdot}00\,\dot{\mathrm{C}}\mathrm{u} : 12{\cdot}07\,\dot{\mathrm{H}}$, representing pretty closely the formula, $2(\dot{\mathrm{C}}\mathrm{u})^{10}\,\dddot{\mathbf{A}}\mathrm{s}+15\dot{\mathbf{H}}$, which requires the oxygen ratio, 7·50 : 15·00 : 11·25.

6. *Lenticular Copper.*

Rammelsberg proposes for this mineral, as analyzed by Chenevix, the formula, $\dot{\mathrm{C}}\mathrm{u}^{10}\,\dddot{\mathbf{A}}\mathrm{s}+30\dot{\mathbf{H}}$, which represents very closely the result of that analysis, and harmonizes well with the formula proposed for the preceding mineral. This formula can be also expressed as follows, $4(\dot{\mathrm{C}}\mathrm{u})^{10}\,\dddot{\mathbf{A}}\mathrm{s}+30\dot{\mathbf{H}}$.

V. SULPHATES.

1. *Melanterite.*

According to Mitscherlich, the formula of sulphate of iron is $\dot{\mathrm{F}}\mathrm{e}\,\dddot{\mathrm{S}}+6\dot{\mathbf{H}}$. According to Graham, on the contrary, it is $\dot{\mathrm{F}}\mathrm{e}\,\dddot{\mathrm{S}}+7\dot{\mathbf{H}}$. The former formula, taking $3\dot{\mathbf{H}}=1\dot{\mathrm{F}}\mathrm{e}$, may be converted to $(\dot{\mathrm{F}}\mathrm{e})^3\,\dddot{\mathrm{S}}$, and the latter to $(\dot{\mathrm{F}}\mathrm{e})^3\,\dddot{\mathrm{S}}+\dot{\mathbf{H}}$. Since protoxyd of iron and water appear to exist always in sulphate of iron in determinate proportions, the former formula, properly speaking, may be expressed more correctly thus, $\dot{\mathrm{F}}\mathrm{e}^3\,\dddot{\mathrm{S}}+2(\dot{\mathbf{H}})^3\,\dddot{\mathrm{S}}$, and the latter also in the same manner, but with $+\dot{\mathbf{H}}$.

2. *Epsomite.* (Beudant.)

The formula thereof is $\dot{\mathrm{M}}\mathrm{g}\,\dddot{\mathrm{S}}+7\dot{\mathbf{H}}$, which is convertible to $(\dot{\mathrm{M}}\mathrm{g})^3\,\dddot{\mathrm{S}}+\dot{\mathbf{H}}$, the remarks appended to melanterite being likewise applicable in this case.

3. *Goslarite.* (Haidinger.)

Its formula is $\dot{\mathrm{Z}}\mathrm{n}\,\dddot{\mathrm{S}}+7\dot{\mathbf{H}}$, which is equivalent to $(\dot{\mathrm{Z}}\mathrm{n})^3\,\dddot{\mathrm{S}}+\dot{\mathbf{H}}$.

4. *Bieberite.* (Haidinger.)

The sulphate of cobalt from Bieber consists, according to Winkelblech, of sulphuric acid 29·05, protoxyd of cobalt 19·91, magnesia 3·86, water 46·83 = 99·65. This gives an oxygen ratio of 17·39 $\dddot{\mathrm{S}}$: 5·74 $\dot{\mathrm{Co}}$ and $\dot{\mathrm{Mg}}$: 13·88 $\dot{\mathbf{H}}$, which is convertible to 17·39 $\dddot{\mathrm{S}}$: 17·66 $(\dot{\mathrm{R}})$: 5·88 $\dot{\mathbf{H}}$, in which case it corresponds very closely to the formula, $(\dot{\mathrm{Co}})^3\dddot{\mathrm{S}}+\dot{\mathbf{H}}$, which requires an oxygen ratio of 17·64 : 17·64 : 5·88. The formula of the artificial sulphate of nickel, $\dot{\mathrm{Ni}}\dddot{\mathrm{S}}+7\dot{\mathbf{H}}$, may be converted in like manner to $(\dot{\mathrm{Ni}})^3\dddot{\mathrm{S}}+\dot{\mathbf{H}}$.

Kopp has examined a sulphate of cobalt from Bieber, the composition of which differed from that analyzed by Winkelblech. It is composed of sulphuric acid 19·74, protoxyd of cobalt 38·71, water 41·55 = 100·00, corresponding to the oxygen ratio, 11·82 $\dddot{\mathrm{S}}$: 8·25 $\dot{\mathrm{Co}}$: 12·31 $\dot{\mathbf{H}}$, which is convertible to—

$$\left.\begin{array}{lll} 11{\cdot}82\,\dddot{\mathrm{S}} & : 12{\cdot}00\,\dot{\mathrm{Co}} & : 25{\cdot}68\,\dot{\mathbf{H}} \\ 12{\cdot}00 & : 12{\cdot}00 & : 24{\cdot}00 \end{array}\right\} \quad (\dot{\mathrm{Co}})^3\dddot{\mathrm{S}}+6\dot{\mathbf{H}}.$$

It would be interesting to ascertain whether this bieberite has the same form of crystal as that examined by Winkelblech, which without a doubt is to be looked upon as the normal salt.

5. *Vitriol.* (Haidinger.)

The formula of sulphate of copper is $\dot{\mathrm{Cu}}\dddot{\mathrm{S}}+5\dot{\mathrm{H}}$. Assuming that $1\dot{\mathrm{Cu}}$ may be replaced by $2\dot{\mathbf{H}}$, this formula is equivalent to $(\dot{\mathrm{Cu}})^3\dddot{\mathrm{S}}+\mathrm{H}$. Sulphate of copper by this means receives a formula similar to that of the other sulphates here mentioned, (with the exception perhaps of melanterite,) and this harmony appears to me to bear out the truth of the assumption I have adopted, and this opinion is still farther supported by the formula obtained by calculation for the phosphates and for the arseniates of copper.

6. *Basic Sulphate of Copper.*

The oxygen ratio of this mineral, resulting from Berthier's analysis, is 9·93 $\dddot{\mathrm{S}}$: 13·35 $\dot{\mathrm{Cu}}$: 15·29 $\dot{\mathbf{H}}$, or otherwise by conversion,

$$\left.\begin{array}{lll} 9{\cdot}93\,\dddot{\mathrm{S}} & : 19{\cdot}33\,(\dot{\mathrm{Cu}}) & : 3{\cdot}33\,\dot{\mathbf{H}} \\ 9{\cdot}75 & : 19{\cdot}50 & : 3{\cdot}25 \end{array}\right\} \quad (\dot{\mathrm{Cu}})^6\dddot{\mathrm{S}}+\dot{\mathbf{H}}.$$

7. *Sulphate of Alumina.*

The formula of sulphate of alumina, both that which occurs native and the artificial, is $\dddot{\mathbf{A}}\mathrm{l}\,\dddot{\mathrm{S}}^3+18\dot{\mathbf{H}}$, which expression may be thus written, $2(\dot{\mathrm{R}})^3\dddot{\mathrm{S}}+\dddot{\mathbf{A}}\mathrm{l}\,\dddot{\mathrm{S}}$. In the artificially prepared pure salt, $(\dot{\mathrm{R}})$ consists entirely of water, whereas in the natural salt, it contains also minute quantities of solid bases isomorphous therewith, as $\dot{\mathrm{Fe}}$, $\dot{\mathrm{Mg}}$, &c.

8. *Alum.*

The alum formula, $\dot{R}\dddot{S}+\dddot{\mathbf{Al}}\dddot{S}^3+24\dot{\mathbf{H}}$, is convertible to

$$3(\dot{R})^3\dddot{S}+\dddot{\mathbf{Al}}\dddot{S}.$$

9. *Alum Stone*, or *Alumite.*

Rammelsberg, from Cordier's analysis of the crystallized alumite from Tolfa, attributes to this mineral the formula, $(\dot{K}\dddot{S}+\dddot{\mathbf{Al}}\dddot{S}^3)+3\dddot{\mathbf{Al}}\dot{\mathbf{H}}$, which involves, as it seems to me, an improbability, inasmuch as one portion of alumina and sulphuric acid are therein combined as a neutral salt, while three times this quantity of alumina, in the form of a hydrate, is noways combined with the acid at all. Changing the expression of the formula to $(\dot{R})^3\dddot{S}+\dddot{\mathbf{Al}}^3\dddot{S}^2$, we get rid of the above improbable ratio.

It cannot but be noticed that in the formulæ proposed for the different (neutral) sulphates, 1 atom $\dot{\mathbf{H}}$ is always introduced as water of crystallization, while six atoms $\dot{\mathbf{H}}=2(\dot{R})$, acting the part of a base, are combined with the sulphuric acid. This coincides very well with Graham's well known observation, to the effect that these salts by exposure to heat, yield up six equivalents of water with far greater readiness than they do the seventh equivalent, which is not expelled until the temperature is still farther raised. Graham termed this last "basic water," and the former water of crystallization. According to my view of the matter, this nomenclature would be inverted.*

At the close of these enquiries, to set about enumerating the numerous facts in favor of the notion that water in the mineral kingdom, acts extensively the part of a base, seems to me a use-less labor, and one which unless entered upon in detail would very likely be imperfect. From all that has been said, it may fairly be held established, That 1 *atom of magnesia, protoxyd of iron, protoxyd of manganese* (probably also) *protoxyd of cobalt, protoxyd of nickel and oxyd of zinc may be isomorphically replaced by* 3 *atoms of water, and that* 1 *atom of oxyd of copper may be similarly replaced by* 2 *atoms of water.* This would be the foundation of a new kind of isomorphism which, contrasted with that hitherto received (monomeric), might be termed *polymeric isomorphism.* There is hardly a doubt but that with time, its application will be found more general.

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* Whether in fact in all the sulphates in question the quantities of the 1 : 1 atomic bases ($\dot{\mathrm{Mg}}$, $\dot{\mathrm{Fe}}$, $\dot{\mathrm{Mn}}$, $\dot{\mathrm{Co}}$, $\dot{\mathrm{Ni}}$, $\dot{\mathrm{Zn}}$, $\dot{\mathrm{Cu}}$) are *always* in *definite* atomic proportion to the amount of basic water [as $\dot{R}:2(\dot{\mathbf{H}})$], a circumstance which, as we have seen, does *not* appear to obtain in other minerals (silicates, phosphates and arseniates), cannot as yet be established for a certainty. But even already from the not unimportant discrepancies observable in the results obtained by various chemists in their analysis of several of these sulphates, it is rendered probable that the ratio between the 1 : 1 atomic bases and the basic water is *variable*. So many other circumstances may however be brought here into play, that no direct proof one way or another is to be sought for therein. This has engaged me to institute a series of experiments directed to the formation of crystallized sulphates in which $\dot{R}$ and $(\dot{\mathbf{H}})$ do *not* observe the definite proportion indicated above. But that such sulphates, if indeed they can exist, are formed only under certain peculiar circumstances, is of itself evident.

There occurs to me an opposite remark of v. Bonsdorff, to the effect that in hornblendes $3\dddot{\mathbf{Al}}$ are apparently isomorphic with $2\dddot{\text{Si}}$, an opinion which is supported by the analogous examples of a similar polymeric replacement mentioned above.*

That polymeric isomorphism is called into play also beyond the region of the mineral kingdom, admits scarcely of a doubt. For the present however, I have no time to follow the subject up beyond its actual limits.

I hold it almost superfluous to remark, that I am far from supposing that *the whole* of the formulæ that I have proposed are the correct ones. For a considerable number of the minerals concerned, especially those with whose composition we are not sufficiently well acquainted, the formulæ are given merely as a suggestion, and further investigation must decide how far I have been correct in such cases as those.

At the conclusion of this article, I may be perhaps permitted to add a few general remarks that appear to me to be of some importance, and which are more or less closely connected with the subject in hand.

1. *Remarks upon the Zeolites.*

Among all the minerals to which our attention has been directed, there is not a single one belonging to the zeolites. This group of minerals is distinguished for its amount of water, and is not the less remarkable from *the total absence of magnesia and protoxyd of iron by which it is characterized, the very two bases which so frequently and with such facility are replaced by water.* The 1 : 1 atomic bases most usually occurring in zeolites, are *lime* and *potash,* with regard to which, as far at least as minerals are concerned, in which they play a leading part, it would appear that they are not replaceable by water. Upon endeavoring to treat either in the whole or in part the water contained in zeolites as basic water, we obtain generally speaking, either highly improbable formulæ, or at least such ones as offer no reason for preferring them to those already received. In a few instances only, which will be found below, the results that I have obtained, appear to be worthy of notice.

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* It is possible that the minute quantities of $\dddot{\mathbf{Al}}$ and $\dddot{\mathbf{Cr}}$ in Schiller-spar (which see) may, upon the same principle, admit of a corresponding quantity of $\dddot{\text{Si}}$.

1. *Okenite.*

$$\dot{\mathrm{Ca}}^3\,\dddot{\mathrm{Si}}^4+6\dot{\mathbf{H}} \text{ may be converted to } 3\dot{\mathrm{Ca}}\,\dddot{\mathrm{Si}}+(\dot{\mathrm{R}})\,\dddot{\mathrm{S}}+3\dot{\mathbf{H}}.$$

2. *Apophyllite.*

$$\dot{\mathrm{K}}\,\dddot{\mathrm{Si}}^2+8\dot{\mathrm{Ca}}\,\dddot{\mathrm{Si}}+16\dot{\mathbf{H}} \text{ may be converted to } 3\dot{\mathrm{R}}^3\dddot{\mathrm{Si}}^2+2(\dot{\mathrm{R}})^3\dddot{\mathrm{Si}}^2.$$

$\dot{\mathrm{R}}$ here contains $\dot{\mathrm{K}}$ and $\dot{\mathrm{Ca}}$; $(\dot{\mathrm{R}})$ on the contrary, the entire amount of water. According to this formula however, the quantity of water in apophyllite should amount to about 18 per cent, whereas both Berzelius and Stromeyer obtained only from 16 to 17 per cent.

3. *Analcime.*

$$\dot{\mathrm{Na}}^3\,\dddot{\mathrm{Si}}^2,\ 3\dddot{\mathbf{A}}\mathrm{l}\,\dddot{\mathrm{Si}}^2+6\dot{\mathbf{H}} \text{ may be converted to}$$

$$3[\dot{\mathrm{Na}}\,\dddot{\mathrm{Si}}+\dddot{\mathbf{A}}\mathrm{l}\,\dddot{\mathrm{Si}}]+2(\dot{\mathrm{R}})\,\dddot{\mathrm{Si}}.$$

The portion of the formula within the bracket is the formula of labradorite. $(\dot{\mathrm{R}})$ here too contains only water.

4. *Harmotome.*

$$\dot{\mathrm{Ba}}^3\,\dddot{\mathrm{Si}}^2+4\dddot{\mathbf{A}}\mathrm{l}\,\dddot{\mathrm{Si}}^2+18\dot{\mathbf{H}} \text{ may be converted to}$$

$$\dot{\mathrm{Ba}}^3\,\dddot{\mathrm{Si}}^2+2[(\dot{\mathrm{R}})^3\dddot{\mathrm{Si}}^2+2\dddot{\mathbf{A}}\mathrm{l}\,\dddot{\mathrm{Si}}].$$

The bracketed portion of the formula is that of scapolite, amphodelite, &c.

5. *Epistilbite.*

$$\left.\begin{matrix}\dot{\mathrm{Ca}}\\ \dot{\mathrm{Na}}\end{matrix}\right\}\dddot{\mathrm{Si}}+3\dddot{\mathbf{A}}\mathrm{l}\,\dddot{\mathrm{Si}}^3+5\dot{\mathbf{H}} \text{ may be converted to}$$

$$\dot{\mathrm{Ca}}^3\,\dddot{\mathrm{Si}}^2+2[(\dot{\mathrm{R}})^3\,\dddot{\mathrm{Si}}^2+2\dddot{\mathbf{H}}\mathrm{l}\,\dddot{\mathrm{Si}}^3].$$

The bracketed portion is the formula of Weissite. The oxygen ratio of epistilbite, deduced from Gustavus Rose's analysis thereof, is

$$30{\cdot}44\,\dddot{\mathrm{Si}} : 8{\cdot}18\,\dddot{\mathbf{H}}\mathrm{l} : 4{\cdot}75\,\dot{\mathrm{Na}} \text{ and } \dot{\mathbf{H}} : 2{\cdot}12\,\dot{\mathrm{Ca}};$$

whereas, according to the formula proposed by me, it ought to be

$$30{\cdot}44 : 8{\cdot}69 : 4{\cdot}35 : 2{\cdot}17,$$

agreeing therefore very closely with the ratio deduced from the analysis. $(\dot{\mathrm{R}})$ in this formula comprises the entire soda and the whole of the water.

Now though there may be somewhat of a probability that some of the zeolites contain basic water, yet it nevertheless seems characteristic of the *zeolites in general*, that the water which they contain is true water of crystallization.

2. *Remarks upon certain Pseudomorphs.*

Not an inconsiderable number of minerals of the most various chemical and crystallographic character, such as spinel, garnet, augite, feldspar, tourmaline, mica, and so forth, are, as is known, met with converted to all appearance into a substance which, according to the external characters that it presents, is termed either steatite or serpentine. We are not however by any means well informed with respect to their precise chemical nature.

Had not aspasiolite which externally resembles serpentine very closely, been accurately examined by me, nothing would have been more probable than holding those crystals, consisting as they do partly of cordierite and partly of aspasiolite, for *crystals of cordierite, partially converted to serpentine*, by which the number of those peculiar pseudomorphs would have been still farther increased. Now as it is moreover established that the crystals of serpentine met with at Snarum, are by no means pseudomorphs of olivine, the inference will not appear too hazarded that, also in the instance of some other serpentine and steatitic masses, hitherto held to be pseudomorphs, further investigation may lead to precisely analogous results. In spinel, garnet, augite, and so forth, a portion of the 1 : 1 atomic bases may easily occur replaced by water, and without a change in the form of its respective crystal being effected, a mineral be formed in its nature approaching serpentine or steatite. Thus, for instance, spadaite and meerschaum, two minerals allied to serpentine and steatite, have the formula of augite, with the difference only that a portion of their bases is replaced by water, in like manner onkosin has the formula of labradorite, pinguite that of garnet, pyrargillite that of fahlunite,—not to cite other examples.

It is not any ways intended to deny that *true* pseudomorphs are met with wherein the magnesia plays an essential part. It is a long established fact that certain metamorphoses are of very frequent occurrence where water impregnated with carbonic acid has exercised a long continued action upon masses of rock from which, in consequence of its solvent properties, it has withdrawn certain constituents. This water, thus charged with carbonic acid *and likewise with other substances*, appears however in certain cases in its progress downwards, to deposit some of these substances again, or rather *to exchange them for others more easily soluble in water containing carbonic acid*, and by this means to give rise to the formation of a particular kind of pseudomorph. Carbonic acid water containing *carbonate of magnesia* in solution, is capable of this action, being able to withdraw from silicates a portion of their more easily soluble bases, especially potash, and to replace them, at least in part, by *magnesia and water.* A solution of carbonate of magnesia in water impregnated with carbonic acid is, as we are aware, distinguished from similar solutions of the other earths by its *alkaline* reaction, and hence it cannot but exercise a far more energetic action upon silicate-masses than, for instance, a solution of carbonate of lime in water impregnated with carbonic acid, the action of which is acid. In this respect the solutions of the alkaline carbonates will naturally display the most powerful action, but as one can easily see, they never bring about any deposition of substances.* Highly interesting proofs may be seen in Norway (in the neighborhood of Arendal), that such a formation of pseudomorphs as is here touched upon, or one at least resembling it, does in point of fact occur, and upon that I purpose entering upon a future occasion.

3. *Remarks upon certain Petrographic and Geognostic relations.*

When we direct our attention to the formulæ proposed for the micas and the micaceous minerals, it cannot escape our notice that in very many of them the same members occur as in the formulæ for feldspar, as for instance $\dot{R}\,\dddot{Si}$, $\dddot{\mathbf{R}}\,\dddot{Si}^3$, $\dddot{\mathbf{R}}\,\dddot{Si}^2$ and so forth, thus indicating a certain connection between two groups of minerals apparently so distinct, and it is this connection which offers an explanation how it is that these groups of minerals are so very frequently met with associated together in crystalline primary rocks. The feldspars and minerals allied thereto are, however, very characteristically distinguished from the micas and the micaceous minerals, inasmuch as the first have never taken up water into their composition, owing doubtless to their 1 : 1 atomic bases, consisting almost entirely of alkalies which do not admit of the entrance of water, whereas it would find easier access to the micas, which contain magnesia and protoxyd of iron. The formula of the mica from Miask, Monroe, and Karasulik, and probably from many other localities, is, as before mentioned, that of garnet;—the formula of the Abborforss and Sala micas approaches the garnet formula, inasmuch as the members thereof are similar though otherwise combined. This would go to explain the circumstance of garnets occurring imbedded in such numerous instances in mica-slate.

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* Besides, the solution of carbonate of lime in water impregnated with carbonic acid, cannot well deposit anything else than *carbonate of lime*, either by a diminution of the free carbonic acid, or by taking up into solution other substances more readily soluble, whereby a portion of the carbonate of lime is, of necessity, separated. That carbonate of magnesia, on the contrary, which gives up its carbonic acid more readily, should be thrown down from such a solution rather than silicate of magnesia (and water), is far more probable. Besides, we may conceive that water which, especially in the case of long enduring action, finds its way into so many compounds otherwise constituted may, so to speak, pave the way to the introduction of magnesia, a body, in a certain point of view, isomorphic therewith.

In conclusion, I now come to the question put already at the commencement of this paper, how is it then, since aspasiolite and cordierite occur close together, that serpentine is not in like manner associated with olivine? It will be readily conceded that water as well as all the other bases in question, cannot but have been present at the formation of aspasiolite and serpentine, (and indeed of all hydrous minerals, occurring as admixtures in primitive formations. But why was it now that that was taken up by the serpentine mass so *through and through* that not even the smallest portion of olivine could exist, while cordierite took up water only *partially*, and became thereby converted to aspasiolite? Before replying to this question we must revert to the formula proposed for these minerals,

Olivine, $\dot{R}^3 \dddot{Si}$. Cordierite, $\dddot{R} \dddot{Si}^2 + 3\dddot{\mathbf{R}} \dddot{Si}$.

Serpentine, $(\dot{R})^3 \dddot{Si}$. Aspasiolite, $(\dot{R})^3 \dddot{Si}^2 + 3 \dddot{\mathbf{R}} \dddot{Si}$.

In olivine, 3 atoms of magnesia are combined with only *one* atom of silica; whereas in cordierite, the same quantity is combined with *two* atoms of silica. Now it is evidently easier that a portion of a base should be supplanted by another basic substance in a compound of the former kind (a one-third silicate), than in one of the latter kind (a two-thirds silicate). Even therefore upon this ground it must be easier for water to make its way into olivine than into cordierite. But that water, at the formation of serpentine actually *prevented* a portion of the magnesia from combining in its place with silica, is proved beyond a doubt by this, namely, that in the Snarum serpentine a mineral occurs imbedded in great abundance (hydrotalcite), the constituents of which are *hydrate of magnesia* and carbonate of magnesia. *There can therefore have been no absence of magnesia at the formation of serpentine, and the water, so to speak, have been thus compelled to be taken up by the silica, but the water, in consequence of its basic properties, has in truth* SUPPLANTED *a portion of the magnesia, and* BY THAT MEANS RENDERED EVERY FORMATION OF OLIVINE OUT OF THE QUESTION. The water could not exert a similar influence upon the cordierite mass from not penetrating it so readily, but was principally taken up thereby *where magnesia was wanting.* That this last was the case, or at least that there was no magnesia present in excess, is established by there being in association with the aspasiolite and cordierite neither free magnesia nor any magnesian mineral capable of giving up a portion of the magnesia which it contains. At the commencement of their formation the last thing that could be wanting to cordierite crystals, was naturally cordierite mass saturated with magnesia; but as these crystals increased in size the magnesia that was wanting was of necessity replaced by water. This explains how it is that the *central portion* of the crystals consist of *cordierite*, while *the parts nearer approaching the surface are aspasiolite.* Since *olivine*, as we have seen above, *cannot be called into existence* where water is present, while *serpentine* for its formation *requires* the presence of water, we are naturally led to the inference that all formations in which olivine occurs could at their origin have contained no water, whereas in all those where serpentine is met with, water necessarily must have been present. And in point of fact the rocks in which olivine occurs are not less by their petrographic character than by their position in the series of geognostic formations, distinctly and thoroughly separated from those in which serpentine is met with. The former belong to the basaltic group, the latter to the crystalline primary rocks.

The Chemical Constitution of the Hydrous Carbonates of Magnesia with reference to Polymeric Isomorphism. (From Poggendorff's Annalen, vol. lxviii, p. 376.)

The different compounds of magnesia with carbonic acid and water have hitherto, as we know, been placed in the following six categories: (1.) Triply hydrous two-thirds carbonate of magnesia $=\dot{\mathrm{M}}\mathrm{g}^{3}\,\ddot{\mathrm{C}}+3\dot{\bar{\mathrm{H}}}$. (2.) Fourfold-hydrous three-fourths carbonate of magnesia $=\dot{\mathrm{M}}\mathrm{g}^{4}\,\ddot{\mathrm{C}}^{3}+4\dot{\bar{\mathrm{H}}}$. (3.) Fivefold-hydrous four-fifths carbonate of magnesia $=\dot{\mathrm{M}}\mathrm{g}^{5}\,\ddot{\mathrm{C}}^{4}+5\dot{\bar{\mathrm{H}}}$. (4.) Triply hydrous, simple carbonate of magnesia $=\dot{\mathrm{M}}\mathrm{g}\,\ddot{\mathrm{C}}+3\dot{\bar{\mathrm{H}}}$. (5.) Five-fold hydrous, simple carbonate of magnesia $=\dot{\mathrm{M}}\mathrm{g}\,\ddot{\mathrm{C}}+5\dot{\bar{\mathrm{H}}}$, and (6.) Magnesia alba, which was held to be a mixture of several of the above named compounds, more especially $\dot{\mathrm{M}}\mathrm{g}^{4}\,\ddot{\mathrm{C}}^{3}+4\dot{\bar{\mathrm{H}}}$ and $\dot{\mathrm{M}}\mathrm{g}\,\ddot{\mathrm{C}}+3\dot{\bar{\mathrm{H}}}$.

Since ascertaining however that, under certain circumstances, water plays a basic part, and this in such a manner that 1 atom $\dot{\mathrm{M}}\mathrm{g}$ is replaced by $3\dot{\bar{\mathrm{H}}}$, the question arises whether the chemical constitution of the whole of these hydrous carbonates, when looked upon in this new point of view, may not become materially modified. The result upon enquiry instituted in this sense, goes to show that the above mentioned compounds, instead of being subdivided under six heads, (the sixth of them consisting itself of compounds incapable of being united under a common formula) may very readily be comprised in two groups.

First Group.

	$\ddot{C}$	$\dot{Mg}$	$\dot{\mathbf{H}}$
1. Triply hydrous two-thirds carbonate of magnesia, according to Fritzsche,	32·67	47·23	20·10
2. Magnesia alba, according to Kirwan,	34·	45·	21·
3. Magnesia alba, according to Klaproth,	33·	40·	27·
4. Magnesia alba, according to Bucholz, .	32·	33·	35·
5. Triply hydrated, simple carbonate of magnesia, according to Soubeiran, .	31·50	29·58	38·29
6. The same compound, according to Berzelius, ...	31·5	29·6	38·9
7. The same compound, according to Bucholz, ...	30·	30·	40·

The relative quantities of oxygen in these compounds are,

1. 23·73 : 18·28 : 17·87
2. 24·72 : 17·42 : 18·67
3. 23·99 : 15·48 : 24·03
4. 23·26 : 12·77 : 31·15
5. 22·90 : 11·45 : 34·60
6. 22·90 : 11·46 : 34·62
7. 21·81 : 11·61 : 35·56

Looking upon the whole of the water contained in these salts as basic, so that one atom $\dot{Mg}$ may be equivalent to $3\dot{\mathbf{H}}$, will so modify the ratios of oxygen as stated above, that the oxygen of the magnesia becomes increased by the third part of the oxygen of the water, giving us therefore,

1. $23{\cdot}73\,\ddot{C} : (18{\cdot}28 + \frac{1}{3}\,17{\cdot}87) = 24{\cdot}24\,\dot{Mg}$
2. $24{\cdot}72 : (17{\cdot}42 + \frac{1}{3}\,18{\cdot}67) = 23{\cdot}65$
3. $23{\cdot}99 : (15{\cdot}48 + \frac{1}{3}\,24{\cdot}03) = 23{\cdot}49$
4. $23{\cdot}26 : (12{\cdot}77 + \frac{1}{3}\,31{\cdot}15) = 22{\cdot}82$
5. $22{\cdot}90 : (11{\cdot}45 + \frac{1}{3}\,34{\cdot}60) = 22{\cdot}98$
6. $22{\cdot}90 : (11{\cdot}46 + \frac{1}{3}\,34{\cdot}62) = 23{\cdot}00$
7. $21{\cdot}81 : (11{\cdot}61 + \frac{1}{3}\,35{\cdot}56) = 23{\cdot}46$

The mean of these seven oxygen-ratios of $\ddot{C} : (\dot{Mg})$ gives us 23·33 : 23·38.

The quantity of oxygen in the acid is therefore precisely equal to that in the base, and consequently these salts, whose composition is apparently so different, whose quantity of magnesia varies from 47·23 to 30, and whose amount of water ranges between 20·1 and 40, may be brought under the common formula $(\dot{Mg})^2\,\ddot{C}$, and be designated by the general title of *semi-carbonate of hydro-magnesia.* With reference to the causes whence it was brought about that the greater or less portion of $\dot{Mg}$ was replaced by $(\dot{\mathbf{H}})$, that is $3\dot{\mathbf{H}}$, it is worthy of remark, that the salt containing the *most water* was formed at a *low temperature* (perhaps between 0° and 10° centigrade), whereas the salt containing the *least water* was formed, with the observance of certain precautions,* at the *boiling point.* This throws out a hint with reference to the possibility of obtaining other salts of magnesia as well, wherein the quantity of water varies.

Second Group.

	$\ddot{C}$	$\dot{Mg}$	$\dot{\mathbf{H}}$
1. Fourfold hydrated, three-fourths-carbonate of magnesia, according to Trolle Wachtmeister,	37·66	43·39	18·95
2. The same compound according to Berzelius,	35·70	44·58	19·72
3. Same compound, according to von Kobell,	36·13	44·12	19·75
4. Magnesia alba, according to Berzelius,	36·47	43·16	20·37
5. Fivefold hydrated, four-fifths-carbonate of magnesia, according to Berzelius,	36·4	43·2	20·4
6. Same compound, according to Berzelius,	36·5	42·8	20·7
7. Magnesia alba, according to Berzelius,	37·00	42·24	20·76
8. Magnesia alba, according to Butini,	36·	43·	21·
9. Fivefold hydrated, four-fifths-carbonate of magnesia, according to Fritzsche,	36·22	42·10	21·68
10. Magnesia alba, according to Bucholz,	35·0	42·	23·

The combinations arrived at by the chemists here named, correspond to the quantities of oxygen stated below:

1. 27·38 : 16·80 : 16·85
2. 25·92 : 17·26 : 17·53
3. 26·27 : 17·08 : 17·56
4. 26·51 : 16·70 : 18·13
5. 26·46 : 16·72 : 18·13
6. 26·53 : 16·57 : 18·42
7. 26·90 : 16·35 : 18·48
8. 26·17 : 16·64 : 18·67
9. 26·33 : 16·29 : 19·30
10. 25·44 : 16·26 : 20·47

Mean 26·39 : 16·67 : 18·35

This is an approximation to the formula $\dot{Mg}^4 \ddot{C}^3 + 4\dot{\mathbf{H}}$, according to which the oxygen ratio should be 26·39 : 17·59 : 17·59. Apparently, therefore, the water contained in carbonates of magnesia constituted as above, either does not act the part of a base at all, or does so only to a small extent; possibly the latter may often obtain with regard to some of the salts quoted towards the end of the above group. We have for instance, in the case of salt No. 9, the oxygen ratio 26·33 : 16·29 : 19·30, whereas it ought to be 26·33 : 17·56 : 17·56. Possibly, therefore, in this compound 1·27 $\dot{\text{Mg}}$ (that is to say 17·56÷16·29), are replaced by 1·74 $\dot{\mathbf{H}}$ (namely 19·30÷17·56), which would be exactly in the ratio required. On enquiring how it is that in fourfold hydrated three-fourths-carbonate of magnesia, no magnesia, or at least very little, is replaced by basic water, the two following circumstances offer themselves in reply. 1. The ten salts that we have mentioned were one and all, obtained at a *boiling heat.* 2. It must evidently be more difficult (from the reasons which I have entered into in the preceding paper relative to the kindred circumstances applicable to aspasiolite and serpentine) for water to find its way into a *three-fourths*-carbonate than into a *semi*-carbonate and expel from thence a portion of the magnesia.

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* See Gmelin's Handbuch der Chemie, New Edition, vol. ii, p. 224.

In addition to the hydrous magnesian carbonates here mentioned, amounting in all to seventeen, which may be ranged in the two groups above described, there are other five that have been analyzed, one of which however may be omitted here inasmuch as prior to its being analyzed (by Dalton), it was dried at a temperature of 100° C. The remaining four are composed as follows:

	$\ddot{\text{C}}$	$\dot{\text{Mg}}$	$\dot{\mathbf{H}}$
1. Five-fold hydrous simple carbonate of magnesia, according to Fritsche,	25·39	23·70	50·91
2. Magnesia alba, according to Bergmann,	25·	45·	30·
3. Do. do. according to Berzelius,	30·25	36·40	33·35
4. Do. do. according to Fourcroy,	48·	40·	12·

The corresponding proportions of oxygen are—

1. 18·46 $\ddot{\text{C}}$: 9·18 $\dot{\text{Mg}}$: 45·31 $\dot{\mathbf{H}}$
2. 16·87 : 17·42 : 26·89
3. 21·99 : 14·09 : 29·64
4. 34·89 : 15·48 : 10·68,

while the formulæ resulting therefrom are—

1. $(\dot{\text{Mg}})^2\,\ddot{\text{C}}+2\dot{\mathbf{H}}$. 3. $\dot{\text{Mg}}^4\,\ddot{\text{C}}^3+8\dot{\mathbf{H}}$.

2. $(\dot{\text{Mg}})^2\,\ddot{\text{C}}+3\dot{\mathbf{H}}$, or $(\dot{\text{Mg}})^3\,\ddot{\text{C}}$. 4. $3(\dot{\text{Mg}})\,\ddot{\text{C}}+\dot{\mathbf{H}}$.

The existence of the second and fourth of these salts must, until established by more accurate experiments, remain a matter of uncertainty. The two compounds alone, the composition of which is ascertained with sufficient precision, are, $(\dot{\text{Mg}})^2\,\ddot{\text{C}}+2\dot{\mathbf{H}}$, $\dot{\text{Mg}}^4\,\ddot{\text{C}}^3+8\dot{\mathbf{H}}$, the oxygen ratio whereof was,

As obtained,	Should be,
18·46 $\ddot{C}$: 18·46 $\dot{M}g$: 17·47 $\dot{\mathbf{H}}$	18·46 $\ddot{C}$: 18·46 $\dot{M}g$: 18·46 H
21·99 $\ddot{C}$: 14·09 $\dot{M}g$: 29·64 $\dot{\mathbf{H}}$	21·99 $\ddot{C}$: 14·66 $\dot{M}g$: 29·32 $\dot{\mathbf{H}}$.

The compound $(\dot{M}g)^2\ddot{C}+2\dot{\mathbf{H}}$ was obtained from sulphate of magnesia by *cold* precipitation, by means of carbonate of potash *with an excess of sulphate of magnesia;* the compound $\dot{M}g^4\ddot{C}^3+8\dot{\mathbf{H}}$, by the evaporation of a concentrated solution of carbonate of magnesia in water impregnated with carbonic acid at a temperature approaching the *freezing point.*

The principal inference to be deduced herefrom, is as follows. All the hydrated magnesian carbonates hitherto analyzed, when made amenable to polymeric isomorphism, may be ranged in two classes: 1. *Semi-carbonate of hydro-magnesia;* and 2. *Four-fold hydrated three-fourths carbonate of* (*hydro-?*) *magnesia.* The salts of the first group, generally speaking, are obtained by precipitation cold, and those of the second group by precipitation at an elevated temperature. In certain exceptional circumstances, in connection especially with a depression of temperature, the compounds of the first class are enabled to take up two atoms more, and those of the second group four more atoms (eight therefore in all) of water of crystallization.